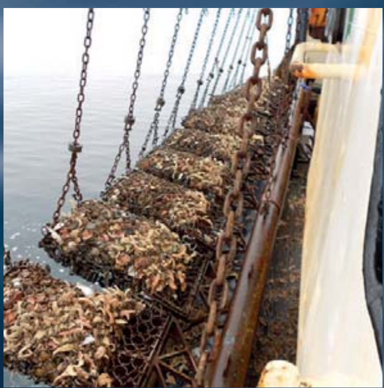
Shellfish Stocks and Fisheries Review 2015



Bord Iascaigh Mhara
Irish Sea Fisheries Board

Marine Institute
Foras na Mara

Shellfish Stocks and Fisheries

Review 2015

An assessment of selected stocks

The Marine Institute and Bord Iascaigh Mhara

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1 Introduction

This review presents information on the status of selected shellfish stocks in Ireland. In addition, data on the fleet (<13 m) and landings for all species of shellfish (excluding *Nephrops* and mussels) are presented. The intention of this annual review is to present stock assessment and scientific advice for shellfisheries which may be subject to new management proposals or where scientific advice is required in relation to assessing the environmental impact of shellfisheries especially in areas designated under European Directives. The review reflects the recent work of the Marine Institute (MI) in the biological assessment of shellfish fisheries.

The information and advice presented here for shellfish is complementary to that presented in the MI Stock Book on demersal and pelagic fisheries. Separate treatment of shellfish is warranted as their biology and distribution, the assessment methods that can be applied to them and the system under which they are managed, all differ substantially to demersal and pelagic stocks. In particular a number of shellfish fisheries are now under Natura 2000 site management regimes.

Shellfish stocks are not generally assessed by The International Council for the Exploration of the Sea (ICES) (with the exception of crab and scallop) and although they come under the competency of the Common Fisheries Policy they are generally not regulated by TAC and in the main, and other than crab and scallop, are distributed inside the national 12 nm fisheries limit. Management of these fisheries, by the Department of Agriculture, Food and Marine (DAFM), is based mainly on minimum landing sizes and increasingly by the use of input or output controls.

A co-operative management framework introduced by the Governing Department and BIM in 2005 (Anon 2005) and under which a number of management plans were developed was, in 2014, replaced by the National and Regional Inshore Fisheries Forums (RIFFs). These bodies are consultative forums the members of which are representative of the inshore fisheries sector and other stakeholder groups. The National forum (NIFF) provides a structure with which each of the regional forums can interact with each other and with the Marine Agencies, DAFM and the Minister.

Management of oyster fisheries is the responsibility of The Department of Communications, Energy and Natural Resources (DCENR) implemented through Inland Fisheries Ireland (IFI). In many cases, however, management responsibility for oysters is devolved through Fishery Orders or 10 year Aquaculture licences to local co-operatives.

The main customers for this review are DAFM the RIFFs, NIFF, DCENR and IFI.

2 Shellfish Fleet

2.1 Fleet capacity

The total registered capacity of the Irish fishing fleet, as of December 2015, was 62,538 gross tonnes (GTs) and 2,114 vessels. The polyvalent general segment is the largest and includes 30,866 GTs and 1,411 vessels. The polyvalent potting segment has 426 registered vessels and 894 GTs (Table 1).

2.2 Fleet structure

The Irish fleet is currently divided into 5 segments. Of these five segments (Aquaculture, Specific, Polyvalent, Beam Trawl and RSW Pelagic) two are broken into sub-segments, namely the Polyvalent and Specific Segments. Aquaculture vessels do not have fishing entitlements. Beam trawl vessels fish mixed demersal fish using beam trawls and RSW Pelagic are large pelagic vessels with refrigerated seawater tanks and target pelagic species. The **Polyvalent Segment** is divided into the following four Sub-segments;

(1) Polyvalent [Potting] Sub-segment; vessels of <12 m length overall (LOA) fishing exclusively by means of pots. Such vessels are also <20 GT. Target species are crustaceans and whelk.

(2) Polyvalent [Scallop] Sub-segment; vessels ≥10 m LOA with the required scallop (*Pecten maximus*) fishing history. These vessels also retain fishing entitlements for other species excluding those listed in Determination No. 21/2013.

(3) Polyvalent [<18 m LOA] Sub-segment;
Vessels with fishing entitlements for a broad range of species other than those fisheries which are authorised or subject to secondary licencing as listed in Determination No. 21/2013 (http://agriculture.gov.ie/fisheries/).

(4) Polyvalent [≥18 m LOA] Sub-segment;
Vessels with fishing entitlements for a broad range of species other than those fisheries which are authorised or subject to secondary licencing as listed in Determination No. 21/2013.

The **Specific Segment**, which entitles vessels to fish for bivalves only, is divided into the following two Sub-segments;

(1) Specific [Scallop] Sub-segment for vessels ≥10 m LOA with the required scallop (*Pecten maximus*) fishing history;

(2) Specific [General] Sub-segment for all other Specific vessels irrespective of LOA.

The size distribution of vessels in the polyvalent segment of the fleet is approximately tri-modal (Figure 1); the bulk of vessels are between 3 m and 10 m in length. These are typical open or half-decked traditional fishing vessels fishing seasonally in coastal waters. There is a smaller peak of vessels between 8-10 m and to a lesser extent between 10-12 m; there is a break in the size distribution at 14-16m with only 8 vessels in this category.

2.3 Fleet capacity transfer rules

The following rules apply to the transfer of capacity within segments;

(1) Polyvalent capacity is privately transferable within its segment. Where an applicant for a polyvalent fishing licence has evidence of holding such capacity (a capacity assignment note) and has an approved fishing vessel then a fishing licence will be issued to such an applicant. This applies to over 18 m and under 18 m sub-segments.
(2) Excluding the fisheries listed in Determination No. 21 the polyvalent capacity is not coupled to any given quota or entitlement. The capacity assignment note simply enables the vessel owner to complete the registration of a vessel and to fish for species other than those in Determination No. 21 but are governed by TAC & Quota and any other harvest control rules that might generally apply.
(3) In the case of fisheries listed in Determination No. 21 the authorisation to fish such stock is effectively coupled with the capacity if the capacity is transferred i.e. this transfer is essentially a transfer of track record in the particular fishery. Such entitlement is, however, also governed by TAC & Quota and any other policies or harvest control rules that might apply to those stocks.
(4) Polyvalent potting capacity is not transferable within its segment other than to first degree relatives of the person to which the capacity is assigned.
(5) Polyvalent general capacity that is not attached to a registered vessel for a period of more than 2 years expires.
(6) When polyvalent potting capacity is no longer attached to a registered vessel then the capacity reverts to the licencing authority. This capacity is not re-issued other than to first degree relatives.

2.4 Vessels targeting Shellfish

The shellfish fleet can usefully be defined as vessels under 13 m in length as the vast majority of such vessels depend largely on shellfish. This cut off, however, is not reflective of any licencing or policy condition. In addition a number of vessels over 18 m target crab mainly in offshore waters (vivier vessels) and 9 vessels over 13 m in length were authorised to fish for scallops in 2015.

The number of vessels in the Shellfish fleet increased by 55% between 2006 and 2015 (Table 2, Table 3). This was predominantly due to regularisation of the potting fleet which were operating outside of the registered fleet prior to 2006 and to registration of existing vessels operating dredges in fishery order and aquaculture licensed areas. The number of vessels in the polyvalent potting segment is declining year on year due to de-registration or transfer from this restricted segment, which limits fishing entitlement. The number of vessels in the polyvalent general segment increased year on year between 2007 and 2012 by an average of 63 vessels per year. This trend was reversed in 2012-2015 during which time the number of vessels declined by 34. The number of vessels in the specific segment declined by 25 vessels from 2012-2015 despite significant increases in fishing activity in some bivalve fisheries.

The average length and capacity of vessels in the polyvalent and specific segments declined between 2006 and 2012. A further decline in the size of specific (bivalve) vessels occurred in

2015. Polyvalent vessels under 13 m in length were on average 0.7 GT smaller in 2014 compared to 2007.

Polyvalent potting vessels have higher engine capacities in proportion to their gross tonnage than polyvalent general vessels. Aquaculture and specific vessels have lower engine capacities compared to polyvalent or potting vessels.

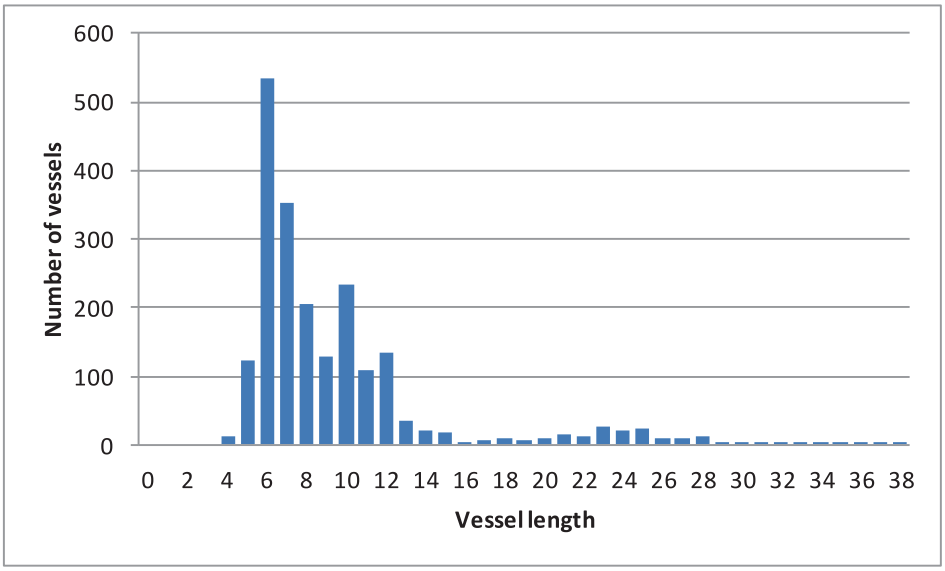

Figure 1. Vessel length distribution in the Irish fishing fleet in December 2015.

Table 1. Capacity (GTs) of Irish fishing fleet segments and sub-segments in December 2015.

		Gross tonnage				
	Vessels	Total	Mean	S.d.	Min	Max
Aquaculture	104	3867	37.18	102.95	0.6	561.0
Beamer	10	1058	105.80	41.04	68.0	196.0
Pelagic	23	23404	1017.57	459.61	325.0	1988.0
Polyvalent General	1411	30867	21.88	56.91	0.2	469.0
Polyvalent Potting	426	895	2.10	2.31	0.3	18.3
Specific	140	2448	17.48	33.59	1.4	187.0
	2114	**62538**				

Table 2. Length and capacity profile of the Irish Shellfish fleet 2006-2015 (<13 m polyvalent, all polyvalent potting, all vessels in specific segment, all aquaculture vessels). Vessels over 18m fishing for crab and scallop are not included.

Segment	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Aquaculture	16	21	39	73	86	96	104	86	89	89
Polyvalent General	953	950	994	1131	1198	1257	1269	1233	1216	1226
Polyvalent Potting	80	492	490	481	467	461	460	454	448	426
Specific	157	117	128	154	150	145	148	137	128	123
Grand Total	1206	1580	1651	1839	1901	1959	1981	1910	1881	1864
Average length of vessels										
Aquaculture	31.62	30.00	21.51	14.75	13.33	12.78	12.46	7.14	7.15	7.10
Polyvalent General	7.95	7.89	7.82	7.67	7.57	7.63	7.51	7.50	7.52	7.53
Polyvalent Potting	7.32	6.74	6.76	6.71	6.67	6.64	6.62	6.62	6.62	6.62
Specific	14.70	13.40	13.22	12.09	12.06	11.71	11.58	11.46	11.23	9.56
Average Gross Tonnage of vessels										
Aquaculture	212.05	197.86	117.30	64.18	54.12	48.87	45.64	2.71	2.72	2.72
Polyvalent General	4.68	4.61	4.38	4.14	3.96	4.30	3.85	3.87	3.91	3.95
Polyvalent Potting	2.96	2.28	2.30	2.22	2.16	2.12	2.10	2.11	2.11	2.10
Specific	38.62	27.34	25.93	20.54	20.29	18.55	18.25	17.93	16.97	7.30
Average kilowattage of vessels										
Aquaculture	468.55	433.79	284.45	166.11	142.51	132.04	126.74	32.48	32.11	32.17
Polyvalent General	35.49	36.46	34.22	31.91	30.61	31.88	29.79	29.61	30.17	30.38
Polyvalent Potting	44.50	29.60	30.29	29.70	28.93	28.28	28.03	28.06	28.23	27.85
Specific	162.81	124.53	114.15	96.99	94.26	90.32	90.28	88.62	85.79	67.15
Kilowatts per GT										
Aquaculture	2.21	2.19	2.42	2.59	2.63	2.70	2.78	11.98	11.81	11.83
Polyvalent General	7.58	7.91	7.81	7.72	7.74	7.42	7.73	7.65	7.71	7.70
Polyvalent Potting	15.03	12.99	13.20	13.39	13.41	13.32	13.35	13.32	13.37	13.26
Specific	4.22	4.56	4.40	4.72	4.65	4.87	4.95	4.94	5.06	9.20

Table 3. Annual percentage change in numbers of vessels per fleet segment in the Shellfish fleet 2006-2015.

	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Annual change in Number of vessels									
Aquaculture	5	18	34	13	10	8	-18	3	0
Polyvalent General	-3	44	137	67	59	12	-36	-17	10
Polyvalent Potting	412	-2	-9	-14	-6	-1	-6	-6	-22
Specific	-40	11	26	-4	-5	3	-11	-9	-5
Annual % change in number of vessels									
Aquaculture	31.25	85.71	87.18	17.81	11.63	8.33	-17.31	3.49	0.00
Polyvalent General	-0.31	4.63	13.78	5.92	4.92	0.95	-2.84	-1.38	-0.05
Polyvalent Potting	515.00	-0.41	-1.84	-2.91	-1.28	-0.22	-1.30	-1.32	0.01
Specific	-25.48	9.40	20.31	-2.60	-3.33	2.07	-7.43	-6.57	0.00
Total	31.01	4.49	11.39	3.37	3.05	1.12	-3.58	-1.52	-1.66

3 Landings 2005-2015

Annual landings of crustaceans and bivalves, excluding *Nephrops* and wild blue mussel (*Mytilus*) seed, which is re-laid for on-growing, during the period 2005-2015, varied from a high of 18,500 tonnes in 2005 to a low of 13,790 in 2009 (Table 4).

Landings data for some species (lobster, periwinkle) in recent years show unexpected changes in volumes relative to say 2004 levels. Spider crab in 2012 was substantially higher than in any previous years. Brown crab landings in 2012 were less than half of their value in 2004. Lobster landings in 2012 were approximately 30% of 2011 landings. Although landings can obviously increase or decline due to changes in effort or catch rates the scale of change in some species, the fisheries that are known to have stable or increasing effort and where catch rate indicators are stable, is contradictory. Other sources of information from industry questionnaires also indicate significant differences between official landings and landings derived from estimates of catch rates, annual individual vessel landings, days at sea and individual vessel fishing effort.

A number of species such as lobster, periwinkle, native oyster and shrimp are targeted by vessels under 10 m in length. As these vessels do not report landings capturing these data is difficult due to the large number of vessels and the small daily consignments involved. Improved tracking of landings by vessels under 10 m would significantly improve data on total landings for a number of species and give a more accurate picture of the economic value of the shellfisheries sector.

Landings data for certain species that are subject to management plans (cockle), that are managed locally (oysters) or where SFPA have analysed gatherers dockets and consignment data to buyers (razor clams) are accurate.

In 2015 the most important species in terms of value were scallop, brown crab, lobster, whelk, shrimp and razor clams.

Table 4. Estimates of annual landings (tonnes) and value (€) of crustacean and bivalve shellfish (excl. prawns and mussels) into Ireland 2004-2015 (source: Logbook declarations and estimates for vessels under 10m). Unit value (per kilo) is from sales note data or other sources. Figures in bold from www.sfpa.ie.

Scientific Name	Common name	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Unit Price	Value 2015
Cancer pagurus	Edible crab	14,217	9,527	10,827	9,251	7,640	6,614	8,622	6,372	6,691	**6,510**	***7,105***	5,878	€1.49	€8,758,220
Pecten maximus	King Scallop	2,471	1,277	742	953	1,322	1,207	1,982	2,476	2,703	3,057	2,552	1,961	€4.90	€9,608,900
Homarus gammarus	Lobster	856	635	625	308	498	431	477	735	249	374	*456*	371	€14.42	€5,349,820
Littorina littorea	Periwinkle	1,674	1,139	1,210	609	1,141	1,103	1,280	64	103	218	1,135	17	€2.00	€34,000
Buccinum undatum	Whelk	7,589	4,151	3,144	3,635	1,947	2,239	2,976	2,828	3,440	2,660	2,172	3,296	€1.42	€4,680,320
Palaemon serratus	Shrimp	405	151	319	325	180	228	135	111	152	157	*301*	250	€10.74	€2,685,000
Ostrea edulis	Native oyster	543	94	233	291	88	327	349	100	*100*	214	265	153	*€4.00*	€612,000
Aequipecten opercularis	Queen scallop	110	75	172	26	4		748	1,002	1,479	285	*100*	31	€0.98	€30,380
Necora puber	Velvet crab	291	245	281	142	268	205	342	160	168	365	*283*	406	€1.99	€807,940
Spisula	Surf clam	28		26	14	55	150	*162*	*73*	15	37	*67*	48	€3.00	€144,000
Maja brachydactyla	Spider crab	180	141	153	70	153	443	415	290	818	229		190	€1.30	€247,000
Palinurus elephas	Crayfish	80	30	34	16	18	28	30	25	33	34	*23*	25	€33.56	€839,000
Ensis spp	Razor clams	400	404	547	356	451	293	410	473	428	723	1,040	840	€5.69	€4,779,600
Chaceon affinis	Red crab	214	294	152	83	44	105	91	106	0	0	*0*	33	€1.28	€42,240
Carcinus maenas	Shore crab	268	27	46	91	72	244	129	74	253	31	*49*	30	€0.99	€29,700
Cerastoderma edule	Cockle	207	107	7	643	9	173	5	401	400	374	*3*	0	€1.70	€0
Veneridae	Venus clam		217	4											€0
Total		29,533	18,514	18,522	16,813	13,890	13,790	18,153	15,290	17,032	14,795	16,003	13,316		€38,648,120

4 Surf clam (*Spisula solida*)

4.1 Management advice

The Waterford estuary surf clam stock is assessed by annual survey and retrospective analysis of LPUE data and size and age composition. TAC is agreed on a voluntary basis at 33% of biomass. Where no biomass estimate is available average catch advice for the preceding years is followed if the commercial catch rate is stable or otherwise discounted for observed depletion in catch rate.

Cumulative landings for the period 2009-2015 exceeded 500 tonnes. Mean commercial LPUE (2009-2015) during the spring fishery was stable although in season depletion was evident especially in 2014. Size and age composition are stable.

Input or output controls should be put in place for other surf clam stocks.

4.2 Issues relevant to the assessment of the surf clam fishery

The spatial extent of surf clam beds is very limited and the species requires particular substrates of coarse sand. There are at least 6 surf clam beds around the coast but not all are fished.

The species is relatively slow growing and long lived. Recruitment appears to be highly variable and the fishery may rely on strong year classes recruiting periodically into the stock. Year on year depletion of biomass, due to fishing mortality, may occur especially if there is no recruitment for a number of years.

Fishery independent survey estimates and age disaggregated catch rate data can provide indicators of trends in stock, biomass and recruitment. Provision of catch and effort data by industry is good and has been a legislative requirement in some cases. This, together with local TAC agreements, has improved the management of the fishery compared to historic 'boom and bust' scenarios.

4.3 Management Units

Surf clam beds exist as discrete locally distributed populations with specific substrate (coarse sand, gravel) requirements. A number of beds exist around the coast; Waterford Harbour, Youghal, at the Sovereign Rocks in Cork, south east Galway Bay, Kilkieran Bay and Clifden. The Waterford Harbour, Clifden and Galway Bay stocks are exploited more frequently than the others. Each clam bed can be treated as a separate management unit.

4.4 Management measures

A voluntary annual TAC agreement of 33% of biomass or average catch advice is in place for the Waterford fishery. Biomass is estimated by annual survey although estimates are considered to be poor. Minimum landing size is 25 mm. Individual vessels cannot land more than 2 tonnes per day. Fishing is limited to 5 days per week and between 07:00 and 13:00 hours each day. Clams must be landed to designated ports of Dunmore East or Duncannon. The intention to fish and the landing port used has to be notified to the SFPA 48 hours prior to fishing (S.I. 221/2011).

4.5 *Waterford estuary*

4.5.1 Size composition 2015

Average size of clams in 2015 survey was 34.6±3.8mm. Modal size increased from 34 mm in 2014 to 37 mm in 2015 (**Figure 2**, **Table 5**).

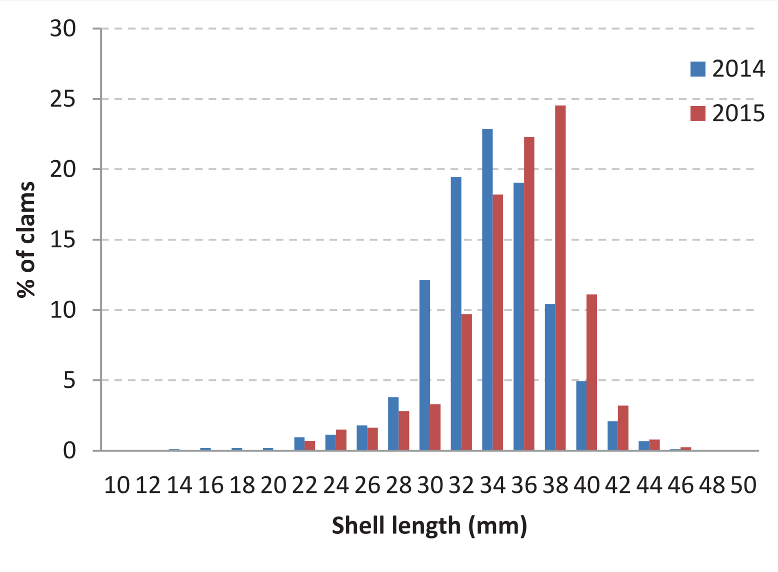

Figure 2. Shell length of surf clams sampled in 2014 and 2015.

Table 5. Mean shell length of surf clams in annual surveys in Waterford estuary 2009-2015.

		Shell length	
Year	N	Mean	S.d.
2009	1188	31.503	3.863
2010	2721	34.072	4.657
2011	1870	29.341	8.646
2012	2782	28.603	5.967
2013	4081	30.078	5.750
2014	1055	33.100	3.963
2015	1280	34.600	3.831

4.5.2 Landings and catch rates 2009-2015

Cumulative landings in the period 2009-2015 exceeded 500 tonnes. Annual average catch rates were stable ranging from 273-483kgs.hr^{-1} although in season depletion was observed in 2014 and to a lesser extent in 2009 and 2010.

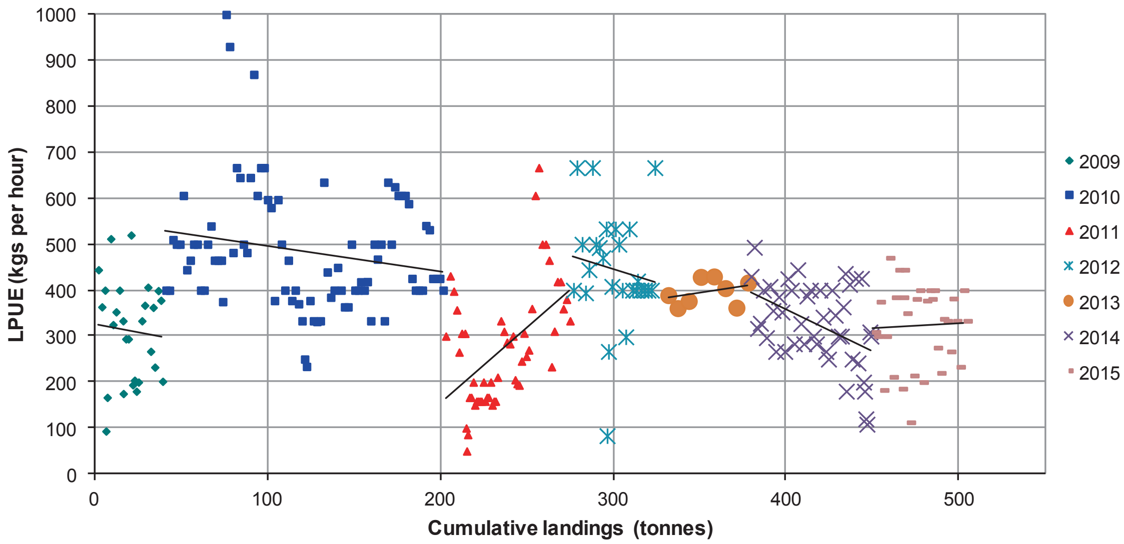

Figure 3. Landing rates (kgs.hr^{-1}) in the Waterford Estuary surf clam fishery in relation to cumulative landings across 2009-2015. In year depletion observed in 2014 and to a lesser extent in 2009 and 2010.

Table 6. Annual average landings per hour in the Waterford estuary surf clam fishery 2009-2015.

	LPUE (kgs.hr-1)	
Year	**Average**	**S.d.**
2009	311.10	109.64
2010	483.13	132.99
2011	273.51	129.79
2012	445.33	124.52
2013	396.06	28.13
2014	327.05	88.13
2015	324.40	89.20

5 Razor clam (*Ensis siliqua*)

5.1 Management advice

Razor clam fisheries are assessed by survey which provide biomass estimates in some cases or otherwise from landings, effort and catch rate indicators and depletion corrected average catch. Weekly TACs apply to vessels in the north and south Irish Sea. All vessels report VMS data. Voluntary TAC agreements are in place for Clifden Bay and Iniskeas Island based on a 20-30% harvest rate.

The north Irish Sea fishery expanded significantly in the period 2011-2015. All indicators (daily landings per vessel, catch per hour) show significant and persistent declines over time. The south Irish Sea fishery opened in 2010 and expanded quickly to 2013. Catch rates were much lower in 2015 than in previous years especially in Rosslare Bay. Much of the fishing effort switched from Rosslare to the Curracloe area in quarter 4. The harvest rate in 2015 in Rosslare Bay was 26%.

Given the escalation of fishing effort and increased landings, considering the high efficiency of the hydraulic dredge gear, the relatively slow growth of Razor clams and the limited distribution of the stocks there is an urgent need to introduce management plans for the Irish Sea fisheries. The sustainable catch is significantly lower than the average landings in the past 5 years as these landings have resulted in severe decline in biomass indicators.

Part of the fishery occurs within Natura 2000 sites in the north and south Irish Sea. The fishery could potentially impact on Common Scoter which feeds on bivalves in shallow water. The conservation objectives for this species and the habitats on which it relies should be integrated into a Razor clam fishery management plan.

5.2 Issues relevant to the assessment of the razor clam fishery

Razor clams (*Ensis siliqua*) occur along the east coast of Ireland in mud and muddy sand sediments from Dundalk to Dublin and from Cahore to Rosslare. The distribution is only known from the distribution of the commercial fishery which operates in water depths of 4-14m. Fishing depth is limited because of the fishing method which uses hydraulically pressurised water to fluidise sediments in front of the dredge. It is likely that razor clam distribution extends to deeper water outside of the range of the fishery as the species occurs at depths of up to 50 m.

The efficiency of the hydraulic dredge used in razor clam fisheries in the UK has been measured at 90%. The dredge, therefore, is very efficient at removing organisms in the dredge track. This is in contrast to non-hydraulic dredges used in other bivalve fisheries such as scallop and oyster where dredge efficiency may be in the region of 10-35%. Selectivity of the dredge is unknown. Discard mortality rates are unknown but may be significant given that damage can be observed on the shell of discarded fish and unobserved shell damage may occur at the dredge head.

Ensis siliqua is slow growing and has relatively low productivity. The apparent resilience to date of the species in areas subject to persistent fishing by highly efficient gears may possibly be explained by immigration of juvenile and adult razor clams from areas outside of the fishery. Some evidence of size stratification by depth has been shown in Wales and given the known mobility of the species suggests that post settlement movement and recruitment into fished areas may occur.

Physical disturbance of sediments and removal of *Ensis* by the fishery potentially alters the bivalve species composition and generally the faunal communities in benthic habitats. In shallow waters changes in the abundance and species composition of bivalves may have a negative effect on diving seaducks (Common Scoter) that feed on bivalves. This species is designated under the Birds Directive in Dundalk SPA in Louth and The Raven SPA in Wexford.

5.3 Management Units

Stock structure is unknown. Larval dispersal and movement of juveniles and possibly adults suggests that the stock structure is relatively open along the east coast of the north Irish Sea and that individual beds are unlikely to be self-recruiting. Fishing is continuous from north Dundalk Bay to Malahide. Stocks in the south Irish Sea are likely to be separate to that north of Dublin given the different hydrodynamic and tidal regimes in the two areas.

Other isolated stocks are thought to occur in many locations on the south and west coasts. Fisheries occur in Clifden Bay and at the Iniskeas Is in Mayo.

5.4 Management measures

New management measures were introduced for the Rosslare – Cahore fishery in December 2014. These include a MLS increase from 100 mm to 130 mm, fishing hours from 07:00 to 19:00, 2.5 tonne quota per vessel per week, 1 dredge per vessel not to exceed 122 cm width and with bar spacing not less than 10 mm, prior notice of intention to fish and advance notice of landing, mandatory submission of gatherers docket information on landings, date and location of fishing, a requirement to transmit GPS position of the vessel on a 1 minute frequency and a defined fishing area to minimise overlap with Natura 2000 sites.

In the north Irish Sea the weekly vessel TAC is 600 kgs (from Jan 1st 2016) with a prohibition on landing on Sundays (SI 588/2015). The fishery was closed during the spawning season in June in 2015.

All vessels fishing for Razor clams must have a functioning VMS system on board and report GPS position at defined frequencies. Only 1 class of production area (A,B,C) can be fished during a fishing trip (SI 206/2015).

5.5 North Irish Sea

The fishery occurs close to the coast in shallow sub-tidal waters along the east coast from Dundalk south to Malahide (Figure 4). The fishery overlaps with the south part of Dundalk Bay SPA in sub-tidal waters and occurs close to a number of intertidal mud and sand flat SAC designations on the east coast. SPA designations include the Common Scoter which feeds on bivalves in shallow subtidal waters.

Annual landings from the Irish Sea, the bulk of which comes from the north Irish Sea increased between 2012-2014 from about 250 tonnes in 2012 to 787 tonnes in 2014 and declined to 707 tonnes in 2015 (Figure 5).

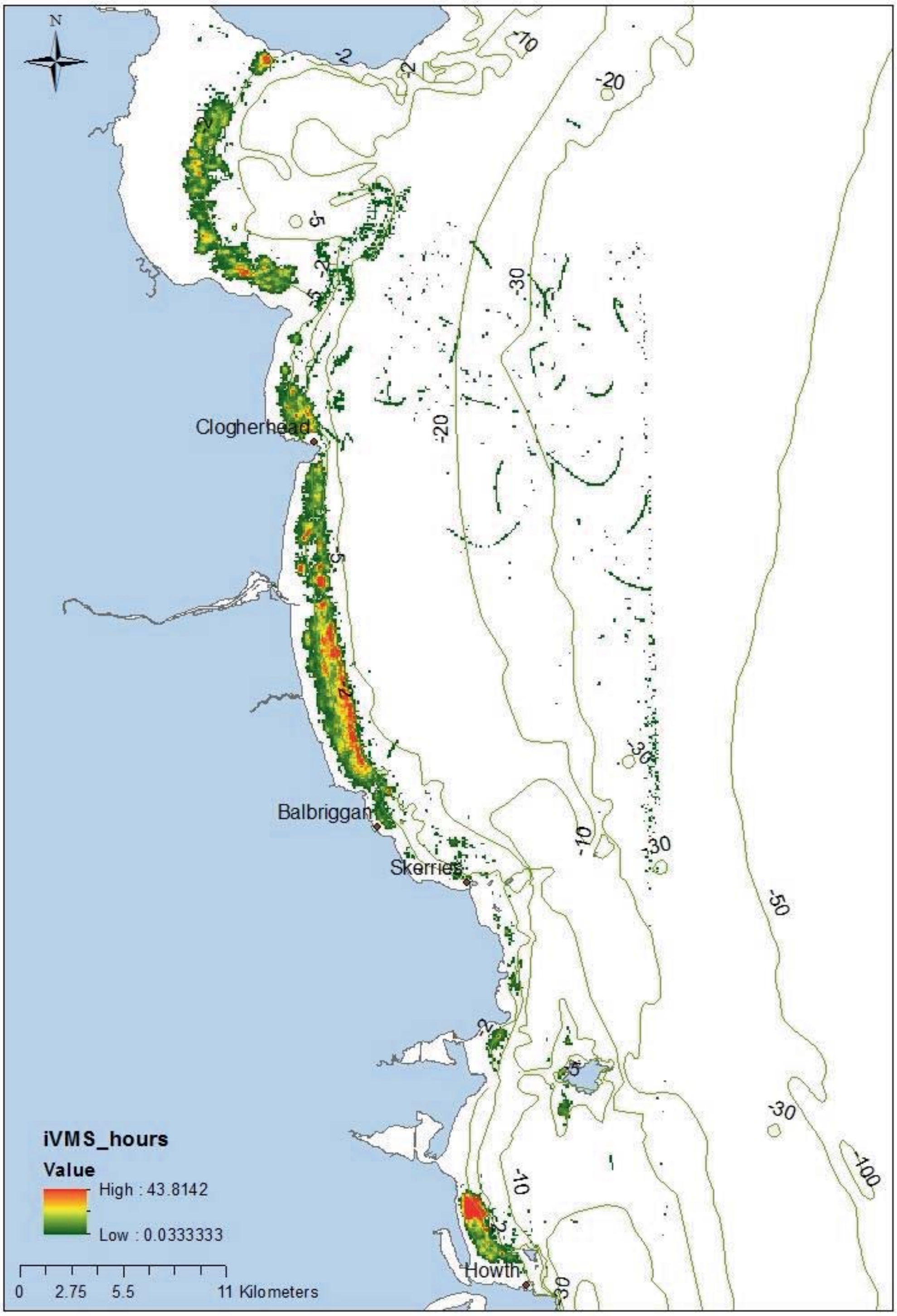

Figure 4. Distribution and intensity of fishing for razor clams based on iVMS data in June to Dec 2015 filtered for speeds of 0-0.75knots which represent fishing activity. The razor fishery occurs in shallow waters of generally less than 10 m depth. Activity further offshore is prawn fishing by the same vessels. Data is cut at -5.95 degrees west.

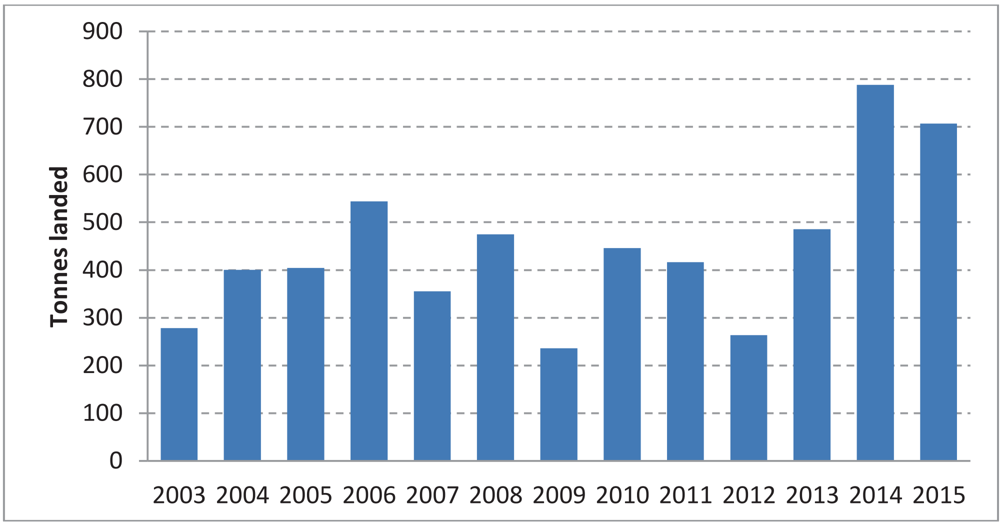

Figure 5. Annual landings of *Ensis siliqua* in the north Irish sea (NIS) 2003-2015 sourced from SFPA logbook data and estimates for vessels under 10m in length.

5.5.1 Stock biomass indicators

Landings per unit effort (LPUE kgs.day^{-1}, kgs.hr^{-1}) were estimated from data on consignments to buyers 2013-2015, from logbooks 2006-2015 and from sentinel vessels 2009-2015.

Daily consignments (kgs.day^{-1}) declined from 300 kgs.day^{-1} in early 2013 to 200 by end of 2015 (Figure 6). Daily declared landings by vessels reporting logbook data (mainly vessels over 10 m in length) declined from an average of 600 kgs.day^{-1} in 2006 to 220 kgs.day^{-1} in 2015 (Figure 7). From 2010-2015 the variability in daily landings was much reduced with few landings over 400 kgs and there was a consistent decline, with some seasonal variability, in average daily declared landings since 2010 (Figure 7). On average the data from April 2006 to September 2015 shows a decline of 3.2 kgs per day per month. Annually averaged declared daily landings shows a remarkably consistent rate of decline between 2006-2015 (Figure 8). This indicates a reduction in daily landings of 47 kg per day year on year and as described above a reduced variability in the daily landings.

The sentinel vessel data provides a more precise indicator of stock biomass in LPUE per hour of dredging. LPUE.hr^{-1} varied from 30-40 kgs.hr^{-1} in 2009-2011 and declined to 20 kgs.hr^{-1} in 2014-2015 (Figure 9).

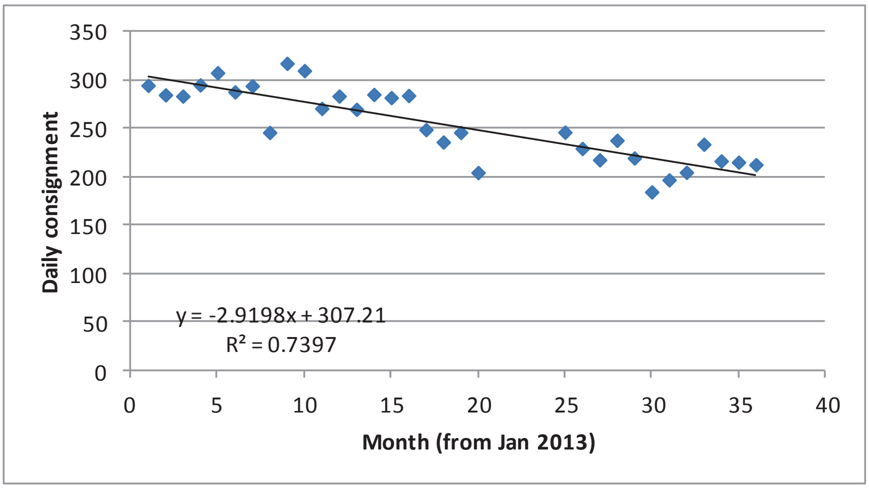

Figure 6. Average daily consignments (kgs) per month recorded in gatherers dockets in 2013-2015 showing a rate of decline of 2.9 kg per day per month in consignment volume.

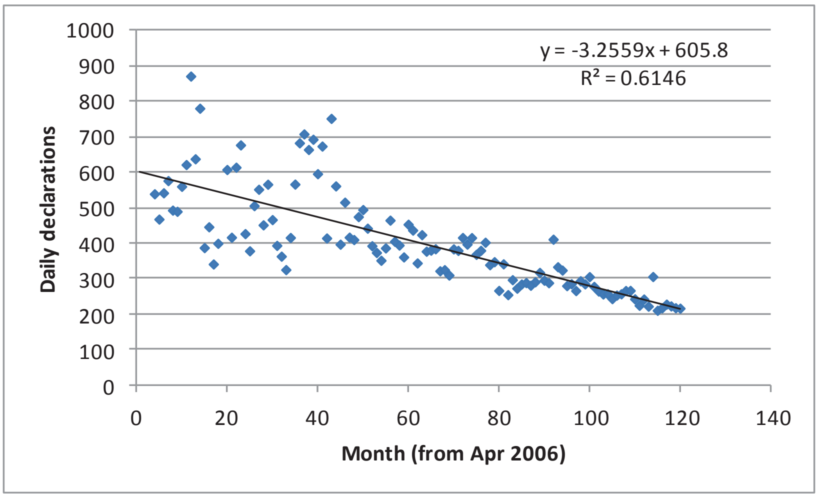

Figure 7. Average daily declarations (kgs) of landings per month from April 2006 with fitted linear regression showing an average decline of 3.25 kg per day per month.

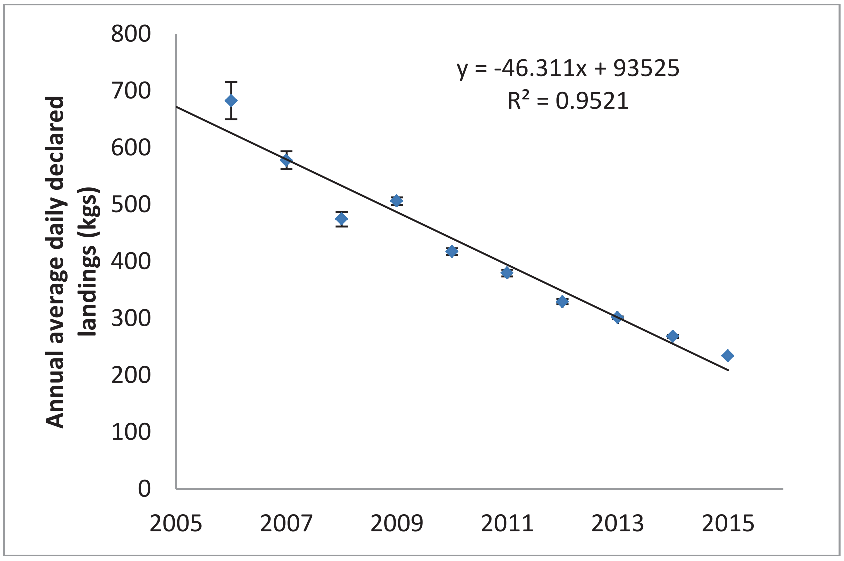

Figure 8. Annual average daily declared landings (kgs) between 2006 and 2015. The line describes an annual decline in daily consignments of 46 kg.

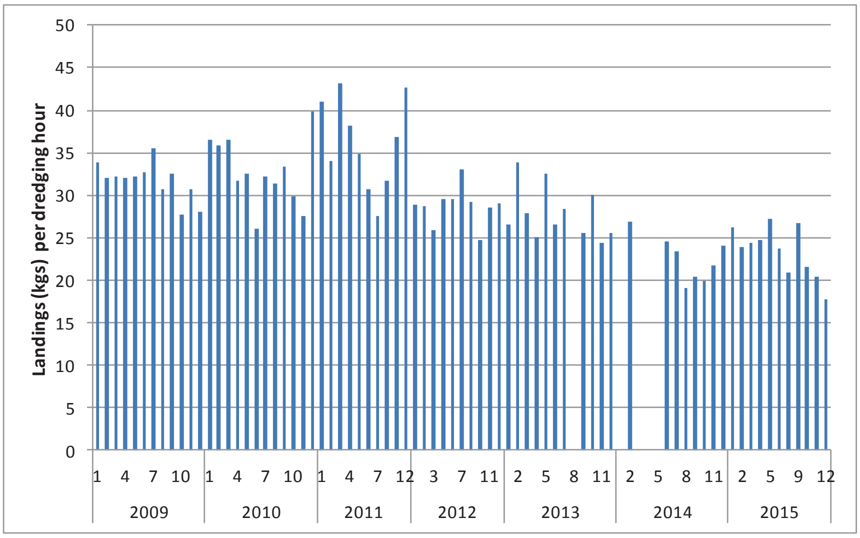

Figure 9. Monthly trends in landings per hour at sea by sentinel vessels reporting between 2009 and 2015.

5.5.2 Catch advice

Where no depletion has occurred during a period of years of the fishery then the average catch during that period could be said to be sustainable and the longer the time series where this condition stands then the higher degree of certainty that this is the case. Where depletion has occurred then the average catch is not sustainable and should be discounted by some proportion, or corrected, for the annual 'windfall' or for landings that resulted in the depletion. This is the depletion corrected average catch (DCAC). After such a correction is done the remaining catch is that which should produce sustainable yields (Y_{sust}) in the long term

$$Y_{sust} = \frac{\sum C}{n + {}^{W}/_{Y_{pot}}}$$

where C is the cumulative catch during (n) years, W is the windfall catch and Y_{pot} is the potential yield defined as $0.4cMB_0$ where B_0 is the initial biomass, M is natural mortality, 0.4 is the proportion of B_0 that results in B_{msy} (empirically from general stock recruit relationships in fish stocks) and c is a tuning adjustment to correct for the assumption that F_{msy} = M. In effect the ratio of windfall catch to potential catch (W/Y_{pot}) = $\Delta/0.4cM$ where Δ is the degree to which biomass has been depleted during the time series. Where there has not been any depletion then Δ=0 and W/Y_{pot} = 0 and the sustainable catch is simply the average catch during the time series.

In the razor clam fishery the average annual landings between 1998-2014 was 378 tonnes (the cumulative landings were approx 6400 tonnes. During this time the stock indicators declined and landings in recent years are over 700 tonnes per annum. The difference between indicator values of starting biomass (1998) and the biomass in the last complete year of the fishery (2015) is approximately 65%. Therefore the average landing of 378 tonnes during the period has resulted in a significant depletion of the biomass which has continued in most recent years. This suggests that the average historic catch of 378 tonnes is too high.

Depletion Corrected Average Catch (DCAC) estimates, based on parameters in Table 7 is 234 tonnes. DCAC estimates are variously sensitive to input parameters such as estimates of the degree to which the stock was depleted during the period of operation of the fishery. DCAC advice (i.e. the likely sustainable annual landings) varies from 375 tonnes (Δ=0.1, or 10% stock depletion) to 246 tonnes (Δ=0.5, or 50% stock depletion). Based on this analysis future annual catches should be lower than 378 tonnes and should probably be closer to 250 tonnes.

There are some mitigating issues which may render this advice overly conservative. Landings data may be under estimated in the past, trends in indicators may be influenced by market conditions and fishing strategies such as high grading and some unexploited stock may occur outside the fishing area.

Table 7. DCAC input parameter values and depletion corrected average catch estimates for Razor clams in the Irish Sea.

Parameter	*Value*
Average M (year-1)	*0.2*
St. Dev. M	*0.5*
Δ	*0.4*
St. Dev. Δ	*0.1*
DCAC advice	*234 tonnes*
DCAC 95% confidence interval	*102-385 tonnes*
Average uncorrected catch	*378 tonnes*

5.5.3 Economic viability of the fishery

Prices increased from €2.21 in 2010 to €5.05 in 2015. Prices increased by 12.7% between 2014 and 2015 (Table 8). This increase was 21% for large and medium grade clams and 0% for small grade clams. The buyers are therefore incentivising fishing for medium and large grade clams.

Other than labour costs diesel is the main operating cost. Other costs have not been estimated at this point and the cost:earnings ratio is unknown. Daily fuel costs increased from 2010-2012 and declined in 2013 and 2014 (Table 5). These trends were mainly due to changes in the price of diesel.

- The number of hours at sea declined marginally in 2014 and further reduced fuel costs.
- Landings per day and per hour declined as described above; the SVP data indicate a decline of 40% between 2010 and 2014 (Figure 11)
- The price that vessel owners obtained for clams increased annually from €2.21 in 2010 to €4.48 in 2014 and to €5.05 in 2015. The price, therefore, increased by over 100% in 5 years (Table 4, 5, Figure 12). Price varies by grade; small grade clam prices are flat and are discouraged by the buyers.
- The net (of fuel) value of the daily landings increased annually from 2011 to 2014 (Table 5, Figure 13)
- The net (of fuel) value of the landing per hour at sea increased from €36 in 2011 to €61 in 2014.

Table 8. Annual trends in fuel costs, hrs at sea, price of clams, LPUE and net (of fuel) value of the catch between 2010 and 2015.

Year	Daily fuel cost	Diesel per L	Hrs at sea	Price of clams per kg	Kgs clams per dredge hr	Net value of daily landings	Net value per hr at sea
2010	€208	€0.65	13.2	€2.21	32.20	€599.00	
2011	€244	€0.80	17.1	€2.54	35.86	€638.00	€36.90
2012	€272	€0.92	14.2	€3.45	28.00	€669.00	€45.60
2013	€227	€0.88	14.7	€3.79	27.26	€695.00	€45.70
2014	€173	€0.79	12.9	€4.60	21.70	€856.00	€61.00
2015	€169	€0.73	12.8	€5.60	23.55	€1,108.00	€85.00

5.6 South Irish Sea

The fishery opened in quarter 4 of 2010 and landings increased annually up to 2013 to over 350 tonnes (Figure 10). The fishery occurs mainly in Rosslare Bay and further north at Curracloe (Figure 11). Approximately 12 vessels fish in the area but this number changes seasonally. The fishery occurs close to or overlaps with a number of SACs and SPAs. The SAC designations to the east of the fishery are mainly sandbanks. Common Scoter, which feeds sub-tidally on bivalves, is designated in the nearby Raven SPA.

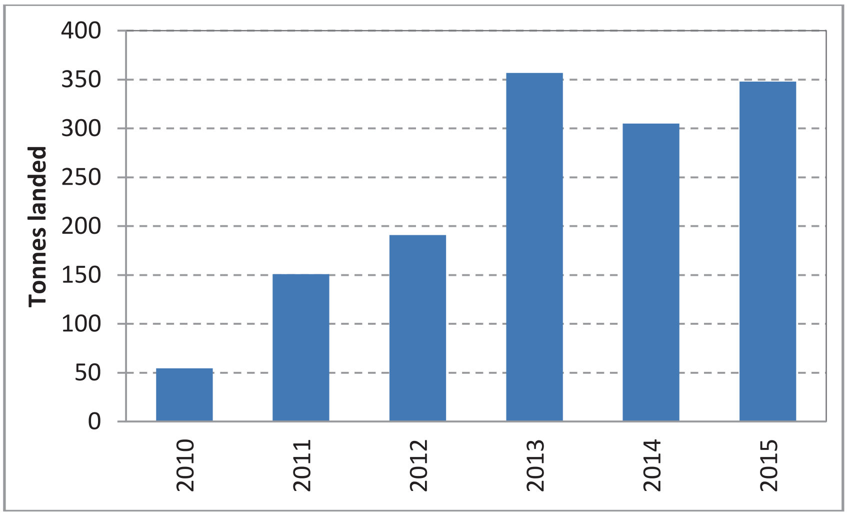

Figure 10. Annual landings of razor clams in the south Irish Sea 2010-2015. The fishery opened in quarter 4 of 2010.

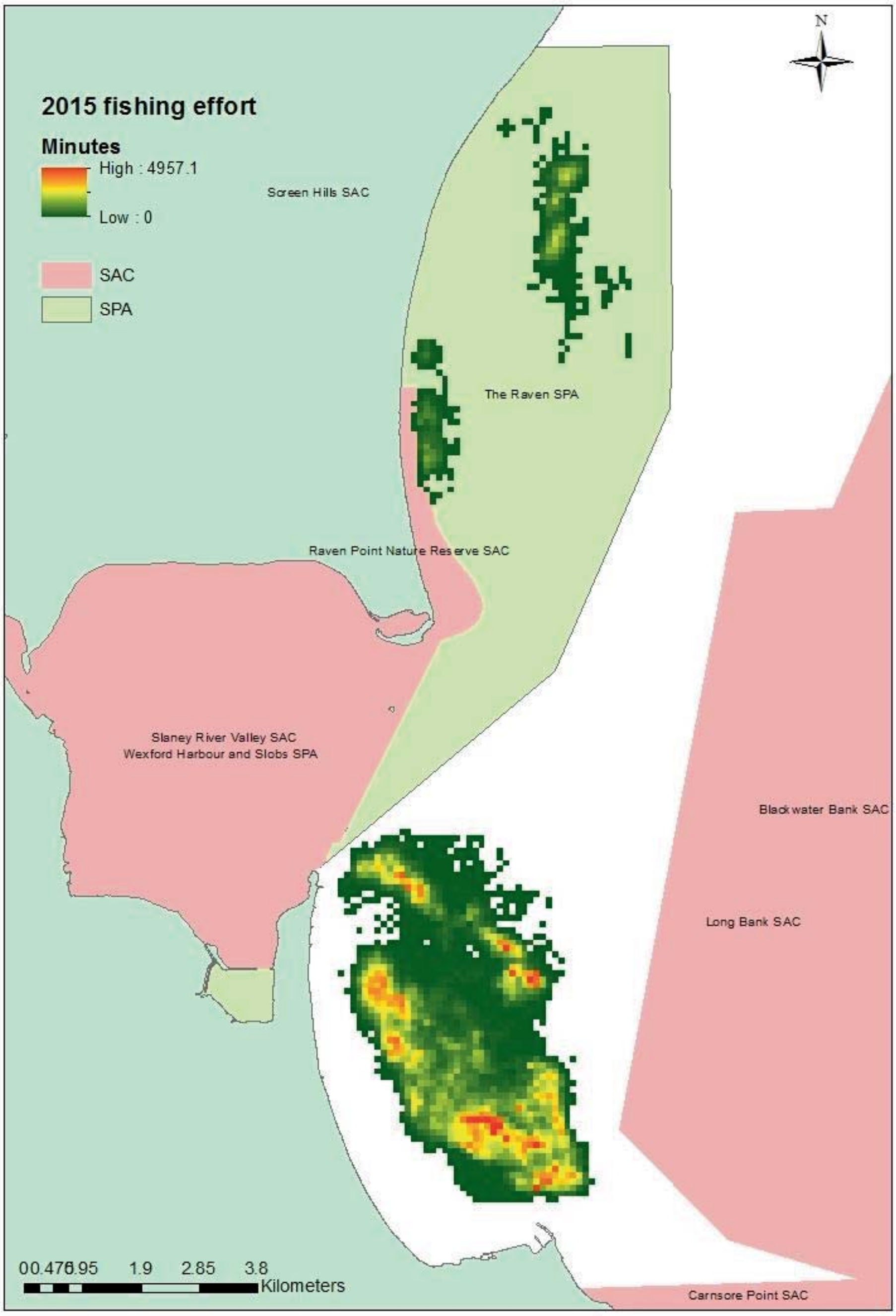

Figure 11. Distribution of fishing for Razor clams at Rosslare and Cahore in relation to the distribution of SACs and SPAs in 2015. Source: inshore VMS data.

5.6.1 Stock Biomass Indicators

5.6.1.1 Logbook data

Logbook trip declarations from 2011-2014 daily landings usually varied from 400-600 kgs (Figure 12). Very high landings (>1000 kgs) may reflect more than one day fishing. In mid 2015 (March-September) catch rates were substantially lower than in any previous year and were below 200 kgs in June and July. Subsequent increase in catch rate in quarter 4 of 2015 was due to a move by the majority of vessels from Rosslare Bay to Cahore (Figure 13).

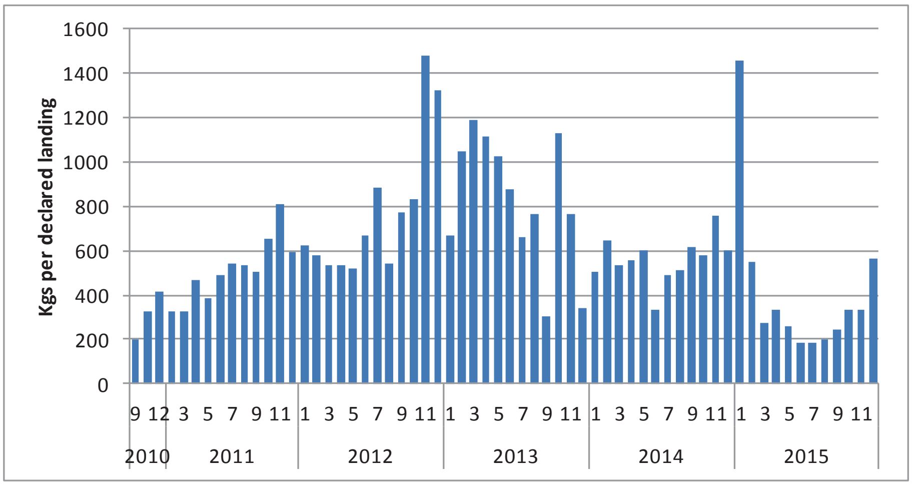

Figure 12. Declared catch rate of razor clams per vessel per day in the south Irish Sea 2010-2015 (Vessels over 10 m).

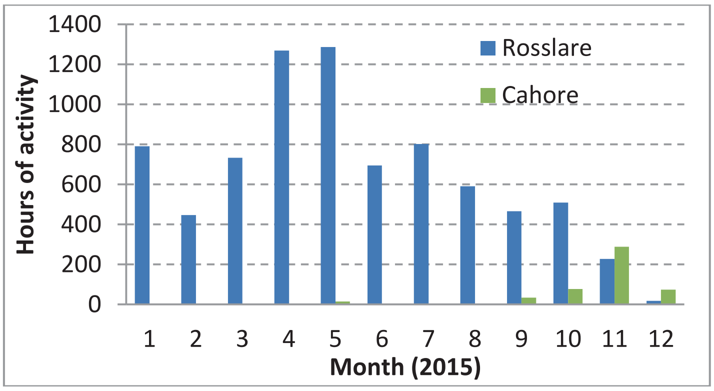

Figure 13. Monthly hours of fishing activity in Rosslare Bay and Cahore in 2015 showing a displacement in fishing effort to Cahore in quarter 4.

5.6.2 Biomass Survey

A survey completed in April 2015 estimated a biomass of 859±69 tonnes in an area of 10.2 km^2 of Rosslare Bay. Razor clam densities ranged from 0-4.4 m^{-2} (Figure 14). The average density across the sampling area was 1.7±0.12 razor clams per m^2. Densities were highest in the south east corner of the survey area and on the western margin close to shore. The edge of the bed was not detected in some areas. The iVMS data (Figure 11) shows that the fishery is distributed over an area of approximately 15 km^2. Raising the survey biomass to the total area over which the fishery occurs therefore suggests a biomass of 1,263±101 tonnes.

Approximately 94% of 2015 fishing effort occurred in Rosslare Bay. If total landings from the south Irish Sea in 2015 (350 tonnes) are discounted by 6% then the harvest rate in 2015 was 26%.

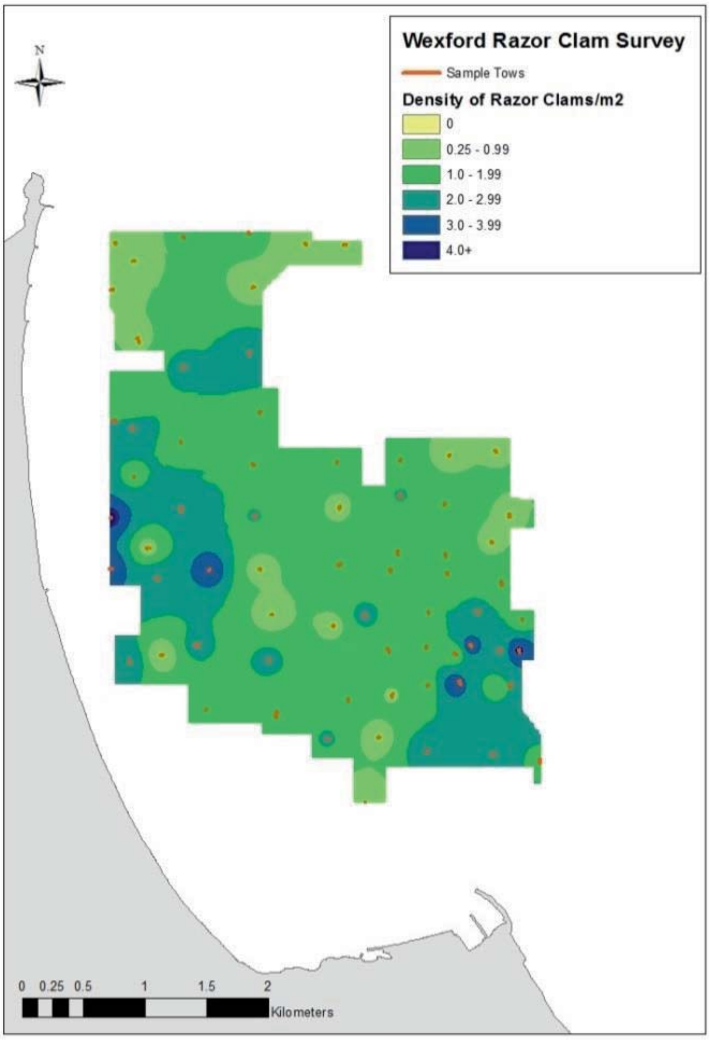

Figure 14. Density distribution of Razor clams in Rosslare Bay in April 2015.

5.6.3 Associated species

A number of bivalves co-occur with *Ensis siliqua* in the Rosslare Bay bed (Table 9).

Table 9. Bivalves associated with Ensis siliqua in Rosslare Bay.

Species	***Total number observed on survey***
Lutraria lutraria (otter shell)	5365
Pharus legumen	2616
Acanthocardia aculeata (spiny cockle)	1996
Mactra stultorum	624
Acanthocardia echinata (spiny cockle)	69
Ensis arcuatus (razor clam)	28
Solen marginatus (grooved razor clam)	15
Arctica islandica (ocean quahog)	3
Spisula solida (surf clam)	3
Chamelea gallina	2

6 Cockle (*Cerastoderma edule*)

6.1 Management advice

Dundalk Bay is managed under a Natura 2000 site fisheries management plan. The Dundalk cockle stock is assessed by annual survey and in season LPUE data. Trends in other ecosystem indicators (benthic habitats, bird populations) are integrated into management advice. TAC is 33% of total biomass on condition that ecosystem indicators for designated habitats and bird populations are stable.

The Dundalk stock declined during the winter of 2009/10 following severe weather and biomass remained low during the period 2010-2015. The fishery did not open in 2014 or 2015. The marine community in intertidal benthic habitats are stable. Bird numbers for a number of species have declined. Cockle biomass is more strongly regulated by larval supply and overwintering survival than by fishing mortality. Bird numbers and cockle biomass are positively correlated

Maintenance of good environmental status in the intertidal habitats in which these fisheries occur is a primary management objective in order to reduce the risk of future recruitment failure and to ensure that conservation objectives for designated habitats and species are protected.

Any cockle fisheries in SACs or SPAs in other areas should be subject to management plans considering their potential effects on designated habitats and birds.

6.2 Issues relevant to the assessment of the cockle fishery

There are a number of cockle beds on the Irish coast. In recent years the main fishery has occurred in Dundalk Bay.

Recruitment of cockles in Dundalk Bay occurs regularly but overwinter survival, in particular, is highly variable. As a consequence biomass, in some years, is insufficient to support a fishery. Recruitment failures occur frequently in the Waterford estuary and overwinter survival is also generally low. In most areas growth rates are lower than in Dundalk and cockles need to survive over 2 winters to reach commercial size compared to 1 winter in Dundalk.

Annual surveys, provided they are completed close to the prospective opening date for the fishery, provide good estimates of biomass available to the fishery and the prospective catch rates. Growth and mortality result in significant changes in biomass over short periods of time.

Dundalk Bay is under a Natura 2000 site management regime and a fishery natura plan for cockles. Cockle is both a characterising species of designated habitats within these sites and also an important food source for overwintering birds. Management of cockle fisheries takes into account the conservation objectives for these habitat and species.

Continuing commercial fisheries for cockles in Natura 2000 sites will depend on favourable conservation status of designated environmental features that may be affected by this fishing activity or a clear demonstration that changes to designated features are not due to cockle fishing.

6.3 Management Units

Cockle stocks occur in intertidal sand and mud habitats. These habitats occur as isolated and discrete areas around the coast and as a consequence cockle stocks occur as locally self-recruiting populations.

Although there are many cockle populations around the coast only Dundalk Bay has supported commercial dredge fisheries in recent years. There is a small scale commercial hand gathering fishery in Castlemaine Harbour (Kerry). Commercial stocks also occur in Tramore Bay and Woodstown Co. Waterford and in Clew Bay Co. Mayo but these stocks have not been commercially fished in recent years. In addition cockle stocks occur in Mayo (other than Clew Bay), Kerry, Sligo and Donegal in particular but these have not been surveyed and are not commercially fished.

6.4 Management measures

The management measures for the Dundalk fishery are described in 5 year management plans (2011-2016 and 2016-2020) and specified in annual legislation in the form of Natura Declarations (www.fishingnet.ie).

In Dundalk Bay a cockle permit is required to fish for cockles either by vessel or by hand gathering. The number of vessel permits is limited to 32. The permit is transferable.

Annual TAC is set at 33% of biomass estimated from a mid-summer survey. The fishery closes if the average catch per boat per day declines to 250 kg even if the TAC is not taken. This provides additional precaution given uncertainty in the survey estimates. Opening and closing dates are specified annually. The latest closing date of November 1st is implemented even if the TAC has not been taken or if the catch rate remains above the limit for closure. Vessels can fish between the hours of 06:00 and 22:00. Maximum landing per vessel per day is 1 tonne. Dredge width should not exceed 0.75 m in the case of suction dredges and 1.0 m for non-suction dredges. The minimum legal landing size is 17 mm but operationally and by agreement of the licence holders the minimum size landed is 22 mm. This is implemented by using 22 mm bar spacing on drum graders on board the vessels.

Environmental performance indicators are reviewed annually as part of the management plans and the prospect of an annual fishery depends on annual evidence that there is no causal link between cockle fishing and in particular the abundance of oyster catcher and other species of bird that feed on bivalves and the status of characterising bivalve species in intertidal habitats.

6.5 Dundalk Bay

6.5.1 Biomass 2007- 2015

Biomass estimates from annual surveys in 2007-2015 are not strictly comparable because of differences in the time of year in which surveys were undertaken (Table 10). The annual estimates are highly sensitive to the timing of in year settlement and seasonal mortality of established cohorts relative to the time in which the surveys are undertaken. The March 2007 survey for instance would not have detected settlement that occurred in 2007. Nevertheless since 2009 surveys have been undertaken either in May or June.

The 2007 biomass of 2,277 tonnes consisted mostly of cockles greater than 18 mm shell width. The fishery in 2007 removed approximately 900 tonnes (including an approximate estimate for hand gatherers) of cockles over 22 mm. Biomass was highest in 2008 due to a strong recruitment in the spring of 2008. The majority of the biomass in 2008 was less than 18 mm shell width and dominated by the 0+ cohort. There was no fishery in 2008. Biomass in 2009 was lower than in 2008 and similar to 2007. This was mainly due to lower densities of 0+ cockles. The biomass in 2010 was approximately 25% of the 2009 biomass and by far the lowest recorded since 2007. The stock in 2010 was dominated, numerically, by recently settled 0+ cockles and a low population density of adult cockles. The 1+ and 2+ cohorts were weakly represented. In May 2011 the biomass was 1,531 tonnes. The population was dominated numerically by 0+ and 1+ cohorts. In 2012 biomass was 1,234 tonnes. The size distribution of cockles was dominated by the 0+ and 1+ cohorts at modal shell widths of approximately 8 mm and 21 mm. In 2013 0+, 1+ and 2+ cohort were strongly represented. Biomass was 1,260 tonnes. In 2014 cockles aged 2+ and older were not abundant. The 0+ cohort was common but not as abundant as in 2012-2013. A 0+A cohort, spawned in Autumn 2013 was present. Biomass was 972 tonnes. The biomass estimate for 2015 was 1,034 tonnes.

Although the stock was not fished in 2008 the biomass was lower in 2009 and lower again in 2010 despite the total landings from the 2009 fishery being only 108 tonnes. Natural mortality appears to have been very high during the winters of 2008-2009 and 2009-2010. This was verified by sampling of a high density patch of cockles from August 2008 to March of 2009 in the middle of the south Bull area. The biomass estimated in 2011 was approximately twice that recorded in 2010. Biomass was stable at 1,200-1,500 tonnes in 2011-2013 and resulted in 3 successive fisheries in autumn of those years. Landings were lower than the TAC in each of these years but especially in 2011. Biomass was lower in 2014. Although the biomass in 2014 was higher than the limit biomass reference point for the fishery to open no fishery occurred. The biomass calculated in 2015 showed an increase on the previous year to 1,034 tonnes, however again no fishery occurred.

Table 10. Annual biomass, TAC and landings of cockles in Dundalk Bay 2007-2015.

Year	Survey Month	Biomass		TAC (tonnes)	Landings	
		Mean	95% CL		Vessels	Hand gatherers
2007	March	2,277	172	950	668	Unknown
2008	August	3,588	1905	0	0	0
2009	June	2,158	721	719	108	0.28
2010	May	814	314	0	0	0
2011	May	1,531	94	510	325	0.25
2012	May	1,234	87	400	394	9.40
2013	June	1,260	99	416	343	0
2014	June	972	188	0	0	0
2015	June/July	1,034	100	0	0	0

6.5.2 Biomass 2015

A pre fishery survey were completed in late June/early July 2015.

In 2015 the total biomass, ± 95% confidence limits, of cockles in the sampling domain (23.7 km^2) was 1,034±100 tonnes (Table 11, Figure 15). Approximately 706 tonnes of this biomass occurred in densities of over 5 m^{-2}, which was 11% up on 2014. The biomass of cockles over 18 mm shell width was 594±47 tonnes with approximately 109 tonnes occurring in densities over 5 m^{-2}. The biomass of cockles greater than 22 mm shell width was 426±38 tonnes. Only 27 tonnes occurred in densities over 5 m^{-2}. Densities were less than 5 cockles.m^{-2} in 60% of the area and less than 10 cockles.m^{-2} in 86% of the area.

Table 11. Distribution of cockle biomass in Dundalk Bay in June/July 2015.

All Cockles (from Quadrat and Rake samples)										
	Area	Density			Weight		Biomass (g^{-2})		Biomass (tonnes)	
Contours	Area (m^2)	N	Mean	95% CL	Mean	95% CL	Mean	95% CL	Mean	95% CL
0	605595	56	0	0	0	0	0	0	0	0
0.25 - 0.99	2474112	49	0.42	0.06	13.10	2.24	5.55	1.20	13.73	2.96
1.0 - 4.99	11222687	123	2.62	0.19	10.73	0.55	28.10	2.53	315.38	28.35
5.0 - 9.99	6127698	65	7.13	0.37	8.85	0.49	63.08	4.77	386.55	29.24
10.0 - 24.99	2884839	42	14.13	1.29	6.24	0.36	88.17	9.55	254.35	27.56
25.0 - 49.99	347574	8	34.22	5.45	5.19	0.48	177.73	32.83	61.77	11.41
50+	10886	1	61.75	0.00	4.78	0.83	295.19	51.48	3.21	0.56
									1,034	**100**

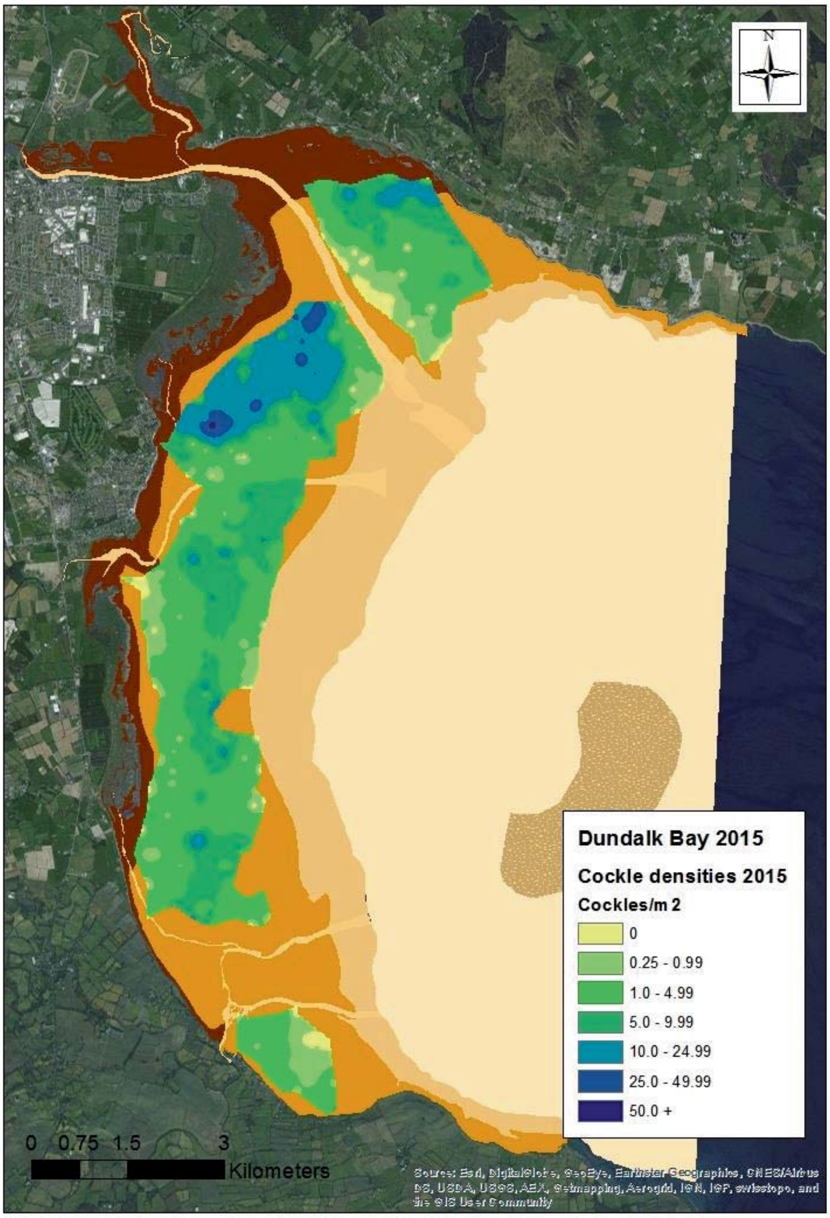

Figure 15. Distribution of cockles in Dundalk Bay in June/July 2015. The surveyed area was 23.7 km^2.

6.5.3 Size and age in 2015

In 2015 the size distribution was bi-modal representing 0+ cockles which settled in spring of 2015 and 2+ cockles (30%). Older cohorts were less abundant in 2015. The higher percent of the 2+ cohort was expected following the strong 1+ cohort, (shell width between 10-20 mm), in 2014 (Figure 16). Between 6-7 age classes were present during 2013-2015 (Figure 17).

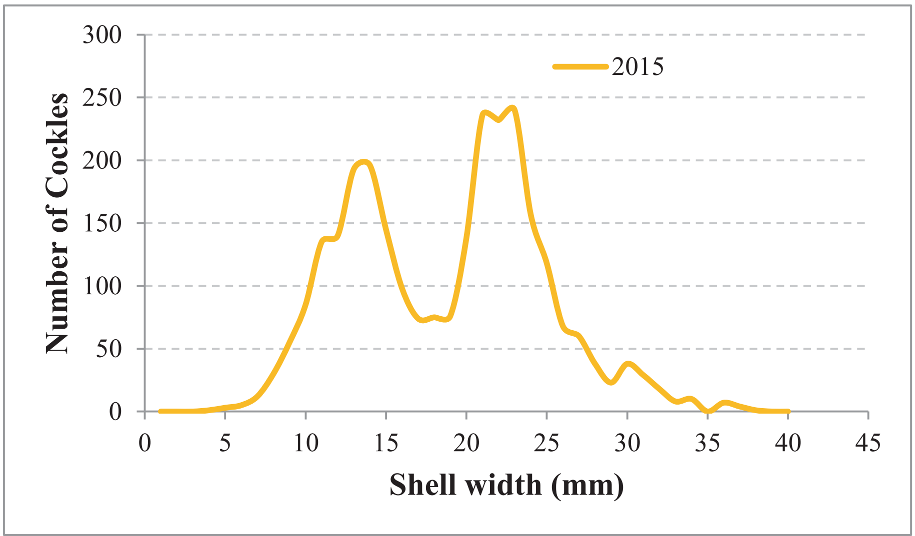

Figure 16. Shell width distribution of cockles in Dundalk Bay in June/July 2015. The operational minimum landing size is 22 mm.

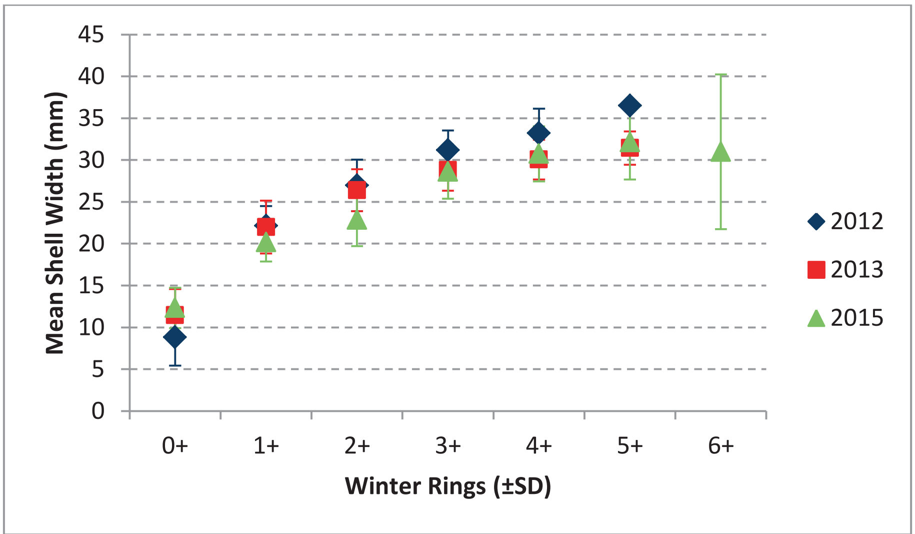

Figure 17. Mean shell width (mm) for 6 age cohorts of cockles recorded from Dundalk Bay in May 2012, June 2013 and June/July 2015.

6.6 Ecosystem indicators

6.6.1 Distribution and abundance of non-target invertebrate species

Density distributions for two bivalve species *Angulus tenuis* and *Macoma balthica* have been recorded since 2011 to detect any changes from year to year in relation to the cockle fishery undertaken in Dundalk Bay.

The spatial distribution of *Angulus tenuis* and *Macoma balthica* was similar in 2013, 2014 and 2015. *Angulus* was more abundant on the mid and lower shores and *Macoma* was more abundant on the upper shore (Figure 18, Figure 19). The mean density of *Angulus* on the lower shore (seaward of the main cockle bed) in 2015 was 70.56±76.90 number.m^{-2}, lower than in the previous two years. Abundances of *A. tenuis* were higher in years 2013-2015 than in 2011-2012 (Table 12).

Both species are short lived and their populations are significantly affected by environmental conditions and predation. These annual variations, as is the case with cockle, probably result from varying overwintering survival and larval settlement during spring.

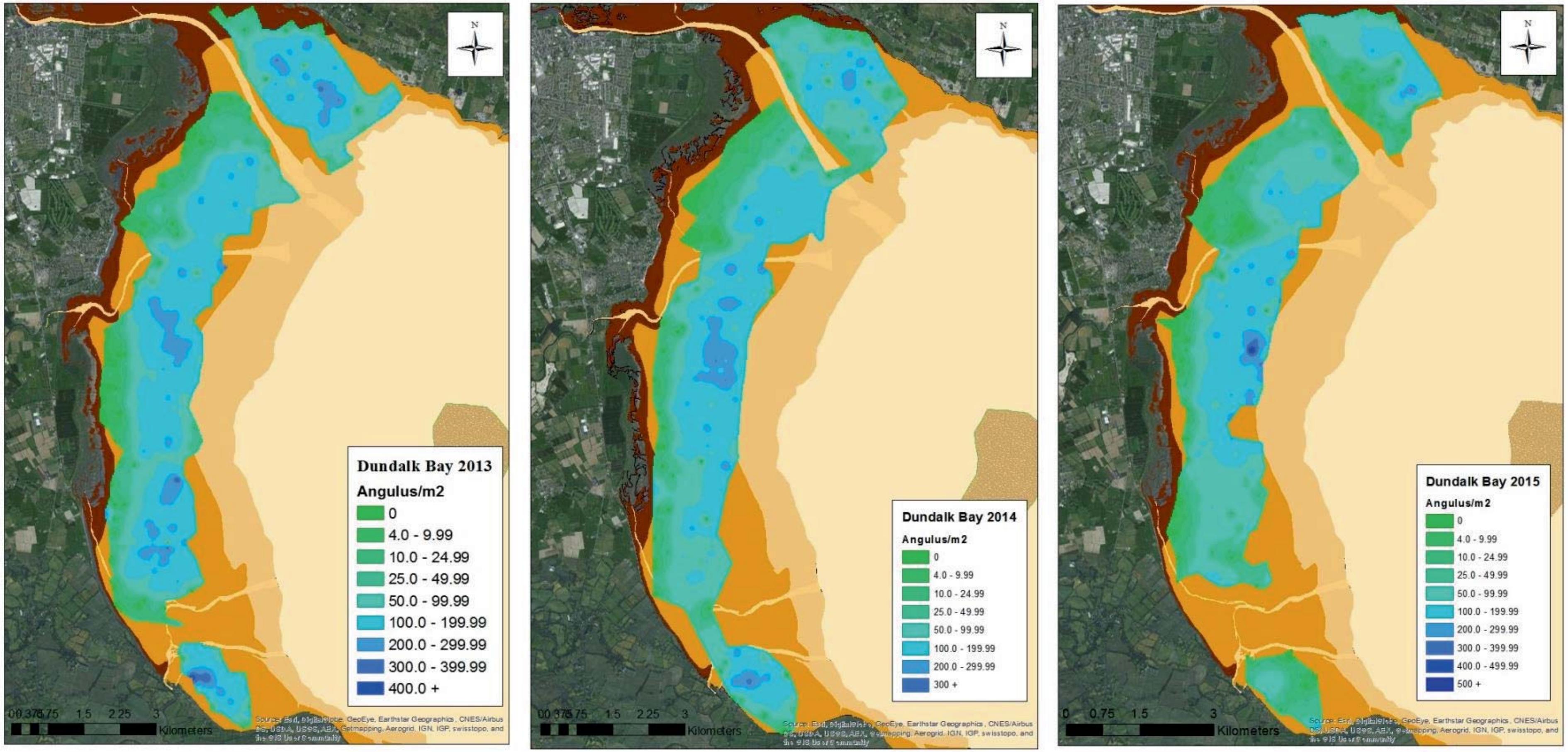

Figure 18. Density distributions of the bivalve *Angulus tenuis* in Dundalk Bay in 2013, 2014 and 2015.

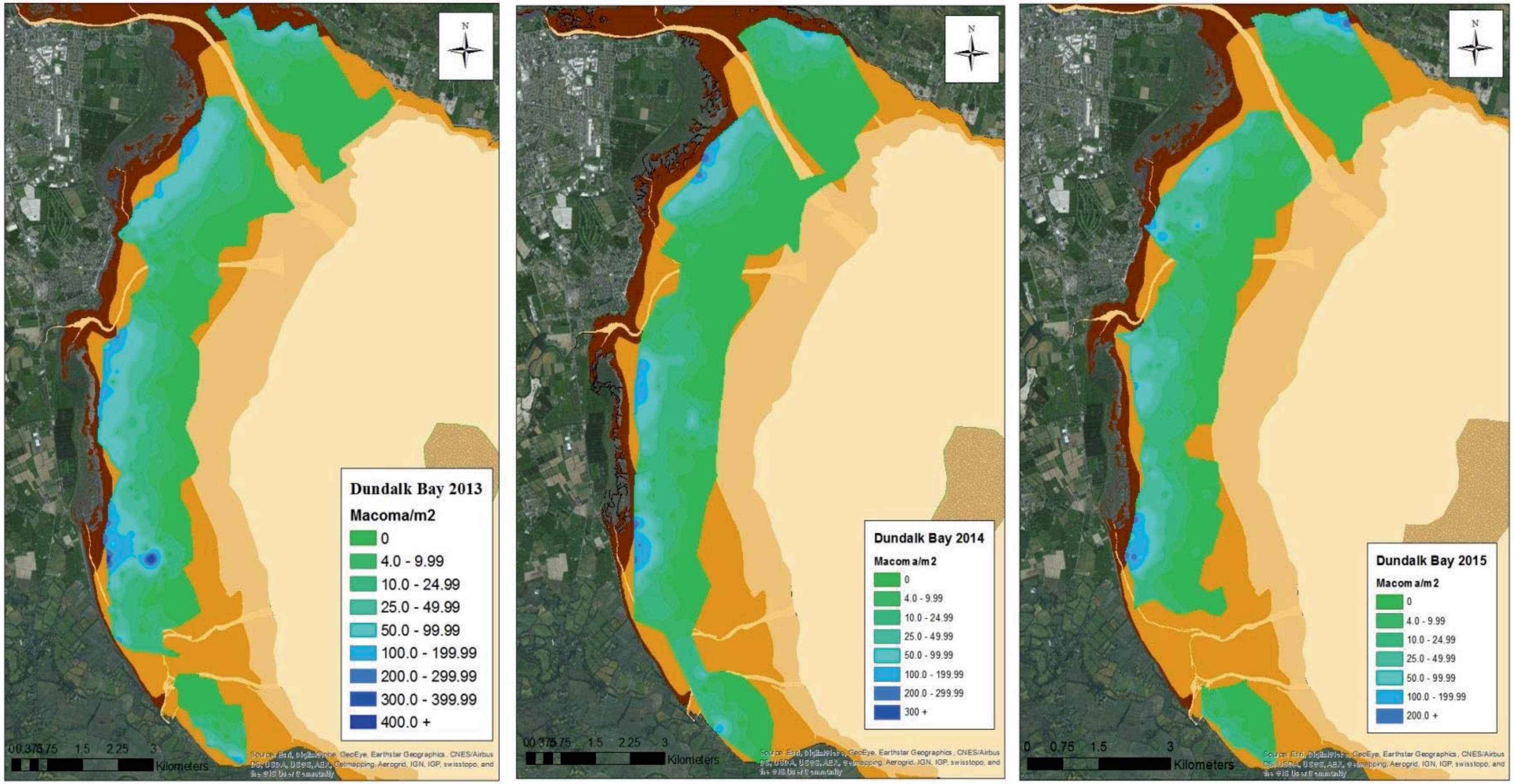

Figure 19. Density distributions of the bivalve *Macoma balthica* in Dundalk Bay in 2013, 2014 and 2015.

Table 12 Annual mean density (number.m^{-2}) of *Angulus tenuis* and *Macoma balthica* in quadrat samples taken in cockle surveys in Dundalk in 2011-2015.

Year	*Angulus tenuis*		*Macoma balthica*	
	Average	S.d.	Average	S.d.
2011	26.14	38.74	13.98	36.25
2012	55.35	62.18	17.74	41.21
2013	95.43	89.82	28.10	57.49
2014	91.61	83.19	18.53	42.23
2015	70.56	76.90	18.80	40.06

6.6.2 Oystercatcher population trends

In the period 2011-2014 two independent surveys of oystercatcher populations were completed; a high tide monthly count by I-WeBS and a low tide monthly count by the Atkins under contract to the MI. Comparison of these data sets shows that the I-WeBS survey can significantly underestimate the number of oystercatcher at the site.

Low tide count data from Atkins are considered to provide an accurate and precise population estimate; for instance successive monthly counts in autumn have shown very similar total number of birds indicating that the count method has repeatability. These data indicate a maximum total population size for 2012/13 of around 10,500 birds (Figure 20). This peak occurred in December-January. The maximum number was just over 11,000 in 2013/14 and occurred in October-November of 2013. Numbers declined rapidly in December 2013-January 2014. Peak numbers of birds remained much lower throughout the autumn of 2014 than in the previous two seasons. The main reduction in numbers occurred in the main sandflats although numbers in the upper shore and outer bay (north and south margins) were also lower. Varying numbers of oystercatcher feed in fields in the countryside surrounding the Bay. Precise estimation of the number feeding in fields is difficult and such counts are usually incomplete. Numbers exceed 1,000 birds on some count dates.

The cockle fishery in 2013 closed at the end of September. Catch rate data suggested a 46% exploitation rate on cockles >22 mm shell width by that time. Numbers of oystercatcher on the main sandflats continued to increase until at least mid-November 2013. The decline in numbers subsequently in December 2013 and January 2014 occurred more rapidly than in previous seasons. It is not known (at time of writing) if this decline also occurred at other sites on the east coast. Numbers of oystercatcher did not re-build to levels seen in 2012 and 2013 during autumn 2014 or 2015. There was no cockle fishery in 2014 or 2015. Densities of *Angulus* were higher in 2013 and 2014 than in previous years. The habitat quality for oystercatcher in 2014 was therefore less favourable than in 2012 or 2013 due to lower cockle biomass although this difference was only about 300 tonnes of cockles. *Angulus* is also taken by Oystercatcher however and was more abundant in 2013, 2014 and 2015 compared to 2011-2012.

6.6.3 Oystercatcher populations and cockle biomass

Between 2007 and 2015 there was an indication of a positive relationship between post fishery cockle biomass (pre-fishery survey biomass minus the landings) and the number of oystercatcher subsequently overwintering at the site (Figure 21); Oystercatcher numbers were over 10000 in the 3 years when cockle biomass was over 1600 tonnes and lower than 9000 in 5 years when cockle biomass was less than 1200 tonnes. The post fishery biomass is estimated from the pre-fishery biomass in June minus the landings. This estimate is uncertain as biomass can increase significantly due to growth between June and August when the fishery starts. This relationship suggests that in some years low cockle biomass limits the number of oystercatcher which the SPA can support and that the baseline population of 8746 birds requires (ecologically) 1600 tonnes of cockles. This is much lower than the ecological food requirement estimate which assumes all the birds energy comes from cockles and again indicates less than 100% dependency on cockles. Also, at cockle biomass of approximately 1000 tonnes oystercatcher numbers ranged from 3234-9000 in the case of iWeBs data and from 6,000-11,300 in the case of low tide data suggesting that cockle biomass is not the only variable regulating oystercatcher numbers in Dundalk Bay. Both these data sets therefore indicate that the baseline population can be supported if cockle biomass in autumn is over 1000 tonnes.

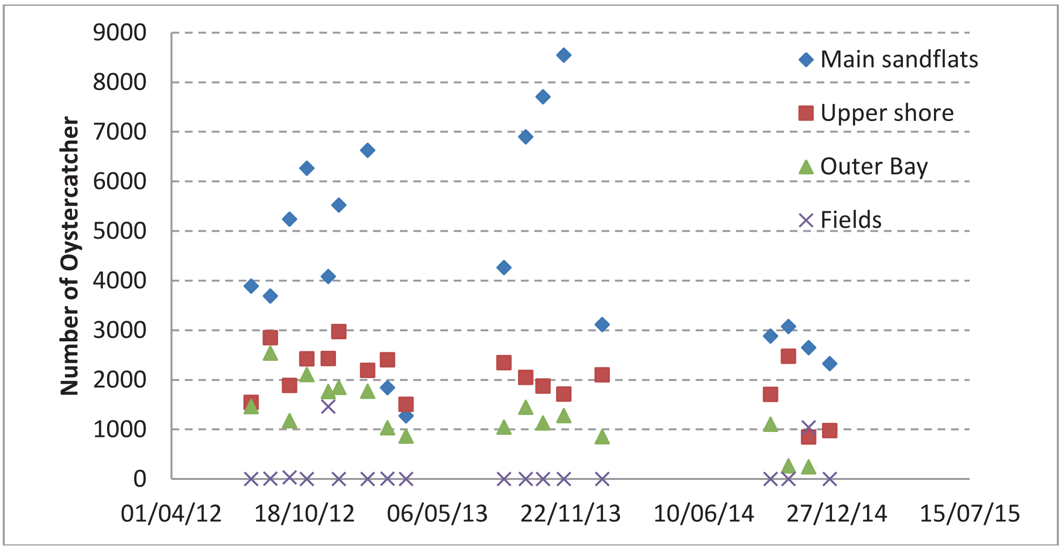

Figure 20. Monthly low tide oystercatcher counts July 2012-December 2014.

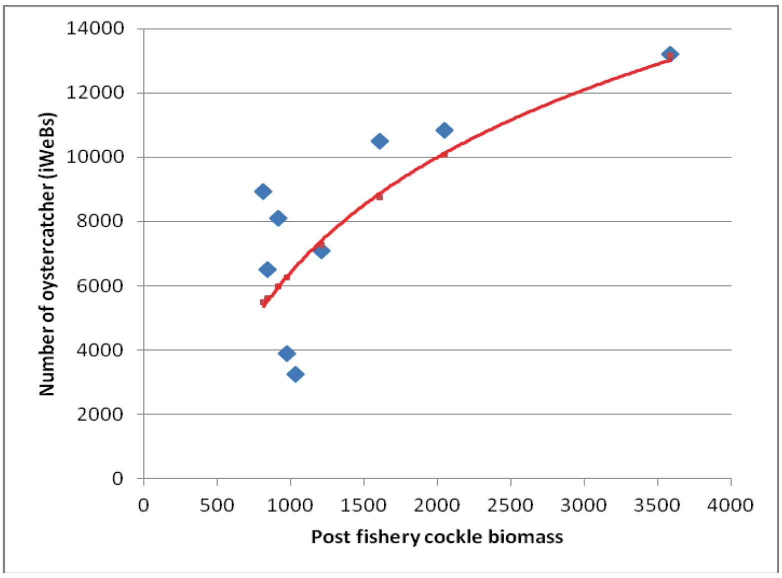

Figure 21. Relationship between oystercatcher numbers (iWeBs data) and post fishery cockle biomass in Dundalk Bay 2007-2016. The fitted curve is a Beverton and Holt stock (cockle) and recruitment (oystercatcher) function R=aS/(b+S), a = 22361 (the asymptote of the curve or carrying capacity) and b = 2507 (steepness) or the cockle biomass required to recruit 0.5 of the asymptotic value. The equation suggests an increase of 269 birds per 100 tonnes of cockles.

7 Oyster (*Ostrea edulis*)

7.1 Management advice

Oyster stocks are assessed by annual surveys which provide biomass estimates although dredge efficiency (catchability) is uncertain.

Stock biomass is generally low in all areas, except Fenit, and management measures to restore recruitment and re-build spawning stocks are necessary. Various threats to native oyster stocks exist including naturalisation of Pacific oyster (*Crassostrea gigas*), *Bonamia* infection, poor habitat conditions for settlement and low spawning stocks.

A commercial fishery for Pacific oyster has occurred in Lough Swilly in recent years. This is preventing the build up of aggregations of the species sub-tidally although the fishery is limited to certain areas only.

Generally, although seasonal quotas and minimum size regulations are in place for some fisheries, management plans or recovery plans should be developed in order to restore productivity to stocks.

Oyster beds are also constituents of habitats designated under the Habitats Directive in many areas. Specific conservation objectives have been defined for these habitats in some sites. Oyster management plans also need to consider the conservation objectives for oyster habitat or for habitat in which oyster is a characterising species.

7.2 Issues relevant to the assessment of the oyster fishery

A number of native oyster beds occur as separate stocks in Bays around the coast. Biomass is currently low, compared to historic levels, in most areas. The Inner Tralee bed holds the majority of the national biomass of native oyster.

Recruitment is variable in most areas although settlement occurred in all areas surveyed in 2015. Larval production and settlement is conditional on density of spawning stock, high summer temperatures and the availability of suitable settlement substrate.

The fishery is managed primarily by a minimum landing size (MLS) of 76-78 mm. The minimum size is generally reached at age 4-5. Oysters generally mature well below the MLS.

Oyster stocks face a number of threats including *Bonamia* infection, which decimated stocks in the 1970s, and is prevalent in a number of beds today. Native oyster is also competing for habitat with naturalised Pacific oyster in some areas. Poor substrate conditions for settling oysters may be limiting recruitment and low stock density may also be reducing reproductive output.

Management authority has been devolved to local co-operatives through fishery orders issued in the late 1950s and early 1960s or through 10 year Aquaculture licences. Although conditions, such as maintaining oyster beds in good condition or having management plans in place, attach to these devolved arrangements in most cases management objectives and management measures are not sufficiently developed. In Lough Swilly and the public bed in inner Galway Bay all management authority rests with the overseeing government department rather than with local co-operatives.

Although management may be devolved through the fishery orders or aquaculture licences vessels fishing for oysters must be registered on the sea fishing vessel register (DAFM) and operators must also hold a dredge licence which is issued by Inland Fisheries Ireland (IFI).

The oyster co-operatives operate seasonal fisheries and may also limit the total catch. The TACs may be arbitrary and scientific advice or survey biomass estimates or other indicators have not generally been used in setting TACs.

All the main oyster beds in Ireland occur within Natura 2000 sites. Oyster is a characterising species of sedimentary habitats of large shallow inlets and bays. It can also be a key habitat forming species in conditions where recruitment rates are high and where physical disturbance is low. Seagrass and maerl or other sensitive reef communities are commonly found on oyster beds in Kilkieran Bay, Tralee Bay, Clew Bay (outer). Dredging may damage these communities. Management of oyster fisheries needs to consider the conservation objectives for this species and its associated habitats and communities.

Annual surveys provide biomass indices or absolute biomass estimates and size structure of oyster stocks annually. Poor information on growth rate, which varies across stocks, limits the assessment of mortality rates and yield predictions.

7.3 Management Units

Oyster stocks occur as discrete isolated units in a number of Bays around the coast. Although native oysters were historically widespread in many areas, including offshore sand banks in the Irish Sea and along the south east coast their distribution is now reduced. The main stocks occur in Tralee Bay, Galway Bay, Kilkieran Bay in Connemara, Clew Bay, Blacksod Bay and Lough Swilly.

7.4 Survey methods

Oyster beds are surveyed annually by dredge. Dredge designs vary locally and those locally preferred dredges are used in the surveys. Dredge efficiencies were estimated in 2010 by comparison of the numbers of oysters caught in the dredge and the numbers subsequently counted on the same dredge track by divers immediately after the dredge tow had been completed.

Surveys are undertaken along predetermined grids where the distribution of the oyster beds is well known. In other cases the local knowledge of the Skipper of the survey vessel is used to locate the beds which, in some areas, are patchy and occur at discrete depths on particular substrates. GPS units with visual display of the local area were used to distribute sampling effort throughout the oyster beds, the boundaries of which were indicated by the skipper of the vessel.

Densities, either converted for dredge efficiency or in raw form, were interpolated using an Inverse Distance Weighting (IDW) algorithm. Contours were drawn at intervals reflecting the range in observed densities. The geographic area inside each contour was calculated and used to raise the average densities and biomass of oysters m^{-2} within each contour to the total population or at least that proportion of the population selected by the dredge.

7.5 Inner Tralee Bay

7.5.1 Distribution and abundance of native oyster in Inner Tralee Bay in 2015

A pre fishery survey was completed on September 8th 2015. A total of 66 tows (average length 87.98±20.23 m) were taken on a pre-determined survey grid. The total area surveyed was 4.51 km^2 and 4,818 oysters were caught.

September 2015 densities, corrected for a dredge efficiency of 17.37%, ranged from 0-32.82 oysters per m^2 (Figure 22), which was lower than the maximum density of 58 oysters per m^2 calculated in 2014. The total number and biomass of oysters in the survey area was estimated to be 16.8 million and 831.1±51.64 tonnes, respectively (Table 13). Approximately 12.2% (101 tonnes) of the biomass was equal to or over the minimum landing size of 78 mm. The percentage of oysters over the MLS is lower than in 2014 (15.1%), but higher than in 2013 (11%) or 2012 (6%).

Oysters ranged in size from 4-111 mm and averaged±sd 54.68±20.44 mm in shell length (Figure 23).

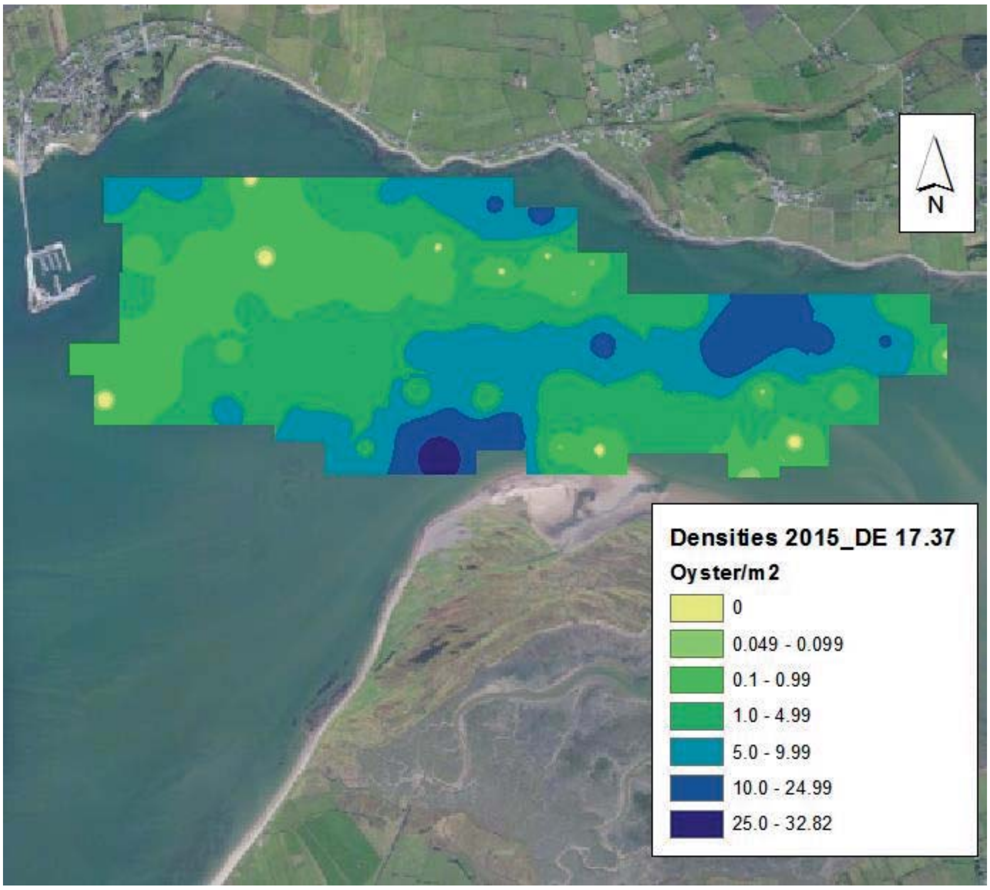

Figure 22. Density and distribution of native oyster in Inner Tralee Bay September 2015.

Table 13. Density distribution and biomass of native oysters in Inner Tralee Bay in September 2015 (corrected for a dredge efficiency of 17.37%).

Density All Oyster (DE 17.37%)	Area (m^2)	N	Mean Density (m^2)	95% CL Density	Biomass (g/m^2)	95% CL Biomass	Total Biomass (tonnes)	CL Biomass (tonnes)
0	17820	10	0.00	0.00	0.00	0.00	0.00	0.00
0.049 - 0.099	26254	4	0.05	0.00	5.16	0.05	0.14	0.00
0.1 - 0.99	1165104	13	0.43	0.04	30.98	2.62	36.09	3.05
1.0 - 4.99	1870509	16	1.96	0.16	116.49	9.48	217.90	17.73
5.0 - 9.99	1052710	13	6.46	0.23	323.91	11.66	340.99	12.27
10.0 - 24.99	346257	8	13.87	1.25	596.10	53.58	206.41	18.55
25.0 - 32.82	33402	1	32.82	0.00	885.59	0.77	29.58	0.03
	4.51 km^2	65					**831.10**	**51.64**

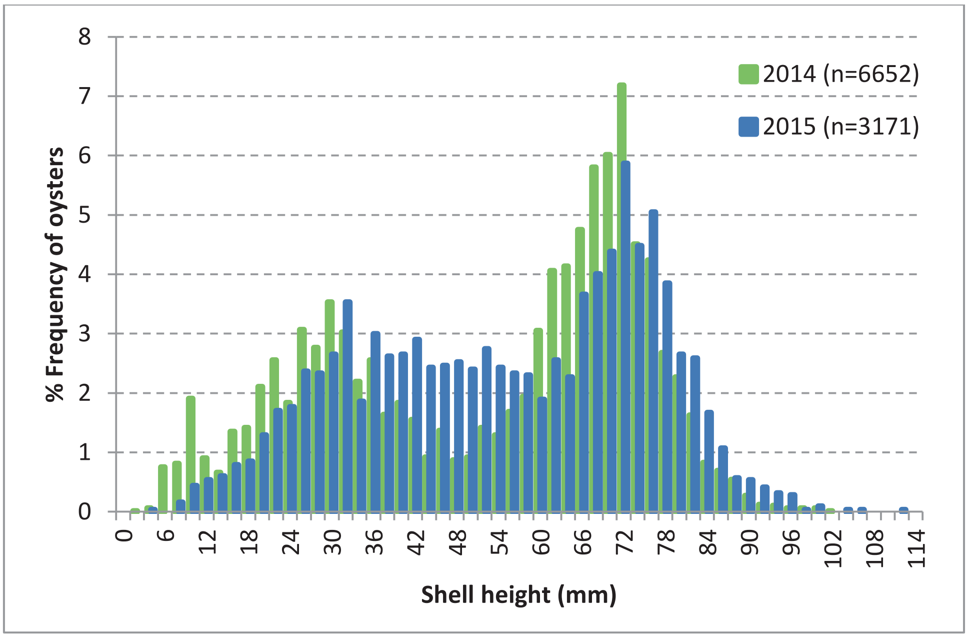

Figure 23. Size distribution of oysters in Inner Tralee Bay in 2014 and 2015.

7.6 Lough Swilly

7.6.1 Distribution and abundance of native oyster (*Ostrea edulis*) in 2015

A pre fishery survey of the oyster beds in Lough Swilly was carried out on the 25th and 26th August 2015. Estimated biomass of native oyster in a survey area of approximately 5.19 km^2 was 33.75 tonnes (Table 14). Densities, uncorrected for dredge efficiency ranged from 0-2.85 oysters m^{-2} (Figure 24). However, densities of 2 oysters m^{-2} or greater were only recorded from two dredge tows. The total number of native oysters was estimated to be 1.74 million. Modal size was 54 mm (Figure 25).

Table 14. Biomass of native oyster in Lough Swilly in August 2015.

Density	Area (m^2)	N	Mean Density (m^2)	95% CL Density	Number of *Ostrea edulis*	Biomass (gms m^2)	95% CL Biomass	Total Biomass (Tonnes)	CL Biomass (Tonnes)
0	76,228	18	0.00	0.00	0	0.00	0.00	0.00	0.00
0.004 - 0.09	1,573,760	31	0.04	0.00	60412	1.02	0.09	1.61	0.14
0.1 - 0.49	2,383,070	44	0.25	0.01	589268	5.23	0.25	12.47	0.60
0.5 - 0.99	835,910	15	0.73	0.03	611886	13.59	0.47	11.36	0.39
1.0 - 1.99	296,892	10	1.34	0.06	397241	23.13	1.00	6.87	0.30
2.0 - 2.85	29,080	2	2.74	0.07	79679	49.77	1.35	1.45	0.04
	5.19 Km^2				**1,738,487**			**33.75**	**1.47**

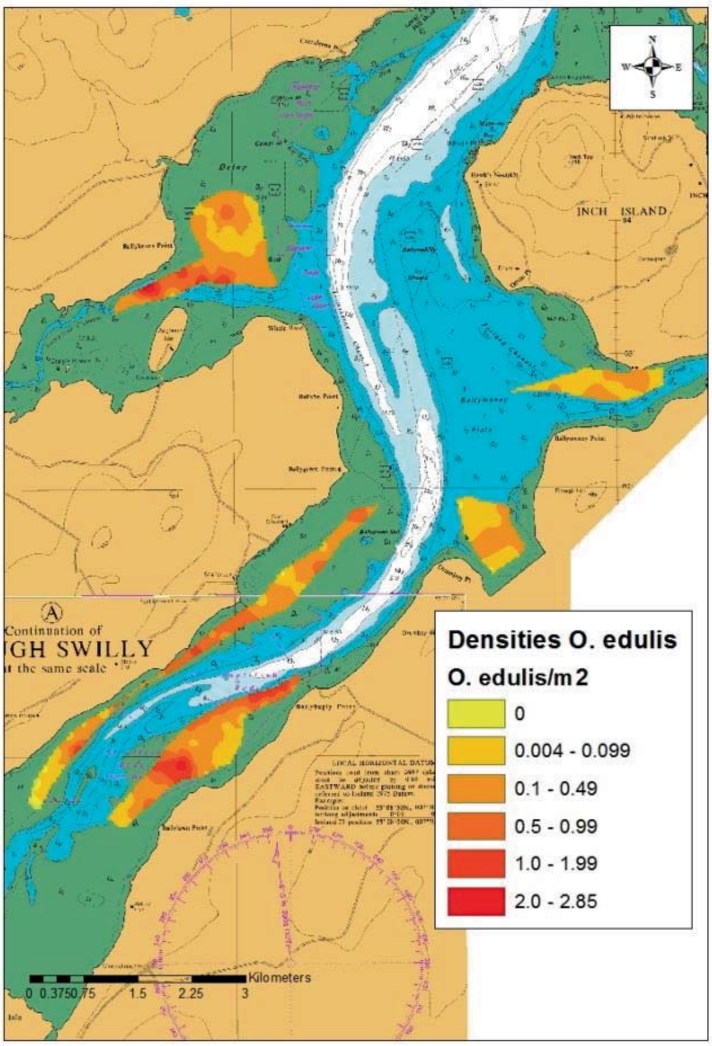

Figure 24. Interpolated distribution and density of native oyster in Lough Swilly in August 2015 (densities not corrected for dredge efficiency).

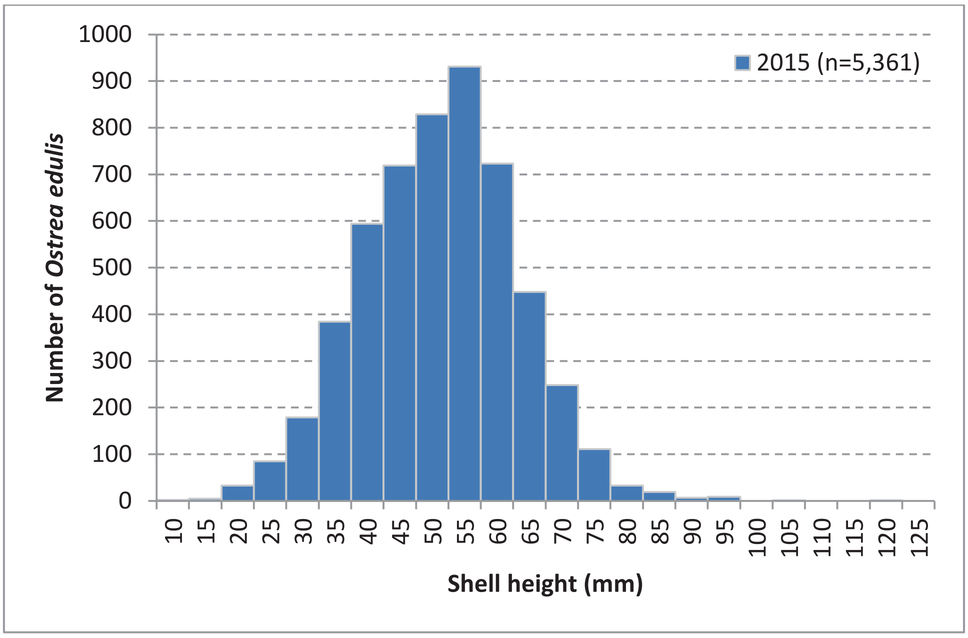

Figure 25. Size distribution of native oyster in Lough Swilly, August 2015.

7.6.2 Distribution and abundance of Pacific oyster (*Crassostrea gigas*) in 2015

The estimated number of Pacific oysters in the survey area of 5.19km^2 in 2015 corrected for dredge efficiency was 1.3 million (Table 15, Figure 26). Size range of *Crassostrea gigas* varied from 14 mm to over 213 mm with an average size of 73.6±25.5 mm (Figure 27).

Table 15. Survey area and number of Pacific oysters within the survey area in Lough Swilly in August 2015.

Density	Area (m^2)	N	Mean density m^2	St. Dev	95% CL density	Number of *Crassostrea gigas*
0	224208	15	0.00	0.00	0.00	0
0.004 - 0.099	1664850	39	0.03	0.02	0.00	56349
0.1 - 0.49	2626070	48	0.24	0.12	0.01	642840
0.5 - 0.99	508966	9	0.66	0.15	0.03	337614
1.0 - 1.71	177645	9	1.35	0.27	0.06	239821
	5.19 Km^2	**120**				**1,276,624**

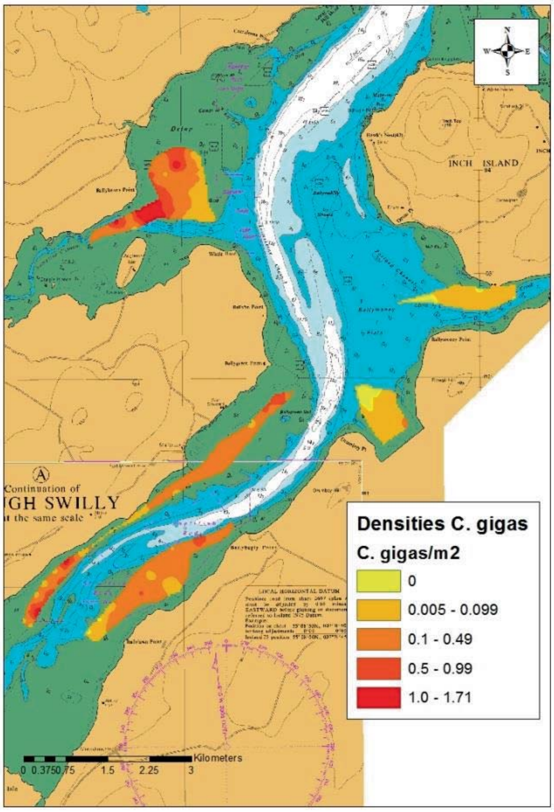

Figure 26. Interpolated distribution and density of Pacific oyster in Lough Swilly, August 2015.

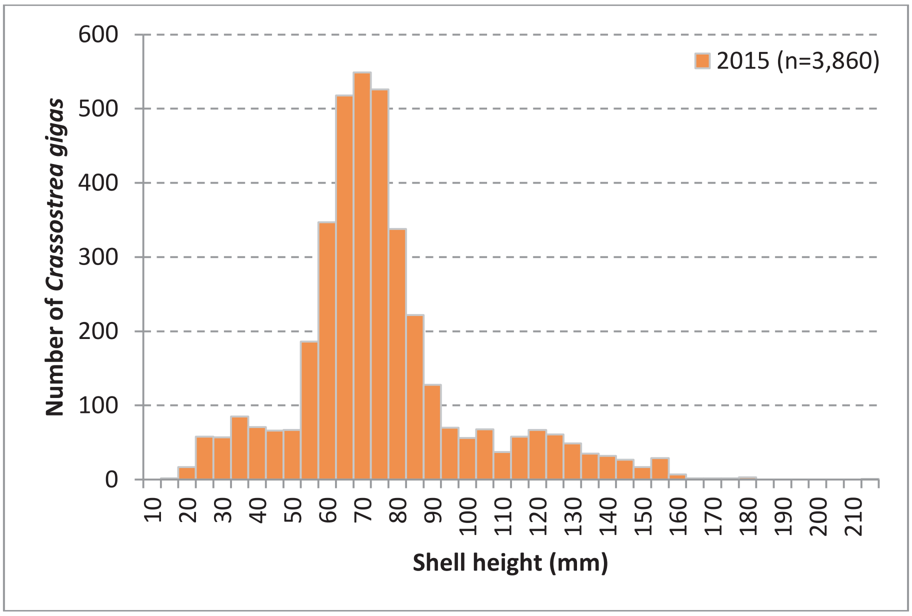

Figure 27. Size distribution of pacific oysters in Lough Swilly, August 2015.

7.7 Galway Bay

7.7.1 Distribution and abundance of the native oyster *Ostrea edulis* in 2015

Due to adverse weather conditions a pre fishery survey could not be undertaken in November 2015. Therefore, a post fishery survey was undertaken in March 2016. A different vessel was used to undertake the 2016 post-fishery survey than in previous years. A total of 26 tows were completed, 21 of which were located on the main bed in Rincarna Bay. Five tows were completed in the fishery order area, at the mouth of the Dunkellin River. The total area surveyed was approximately 0.7 km^2 in extent and 2,459 native oysters were captured. A total of 2,125 native oysters were measured.

Oyster densities, corrected for 35.5% dredge efficiency, ranged from 0.13-10.3 oysters per m^2 (Figure 28). The total number and biomass of oysters in the survey area was estimated to be 3 million and 78.0±15.9 tonnes, respectively (Table 16). Approximately 21.8% (17 tonnes) of this biomass was over the minimum landing size of 76 mm

The average shell size was 46.5±20.3 mm, ranging from 3-96 mm. The distribution of shell size had two main modes at 40 mm and 68 mm (Figure 29).

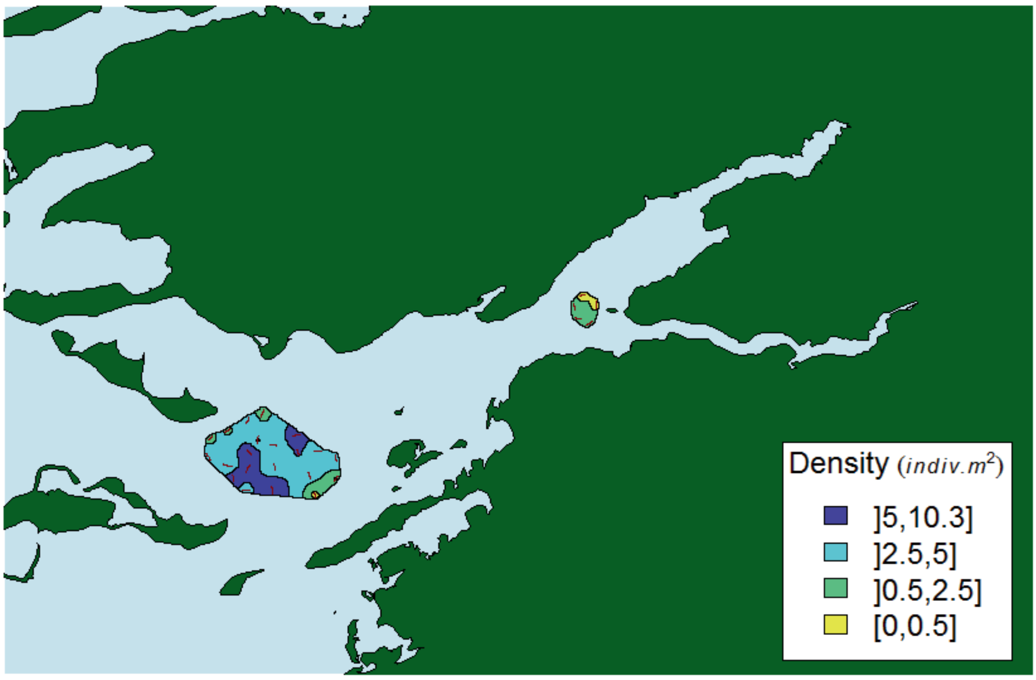

Figure 28. Distribution and density of native oysters (*Ostrea edulis*) in south east Galway Bay March 2016.

Table 16. Distribution of native oyster (*Ostrea edulis*) biomass in south east Galway Bay in March 2016 assuming a dredge efficiency of 35.5%.

Density	Area (m^2)	N	Mean density (ind/m^2)	St. Dev	95% CI density	Number of oysters	95% CI Number	Biomass (g/m^2)	95% CI Biomass (g/m^2)	Total biomass (tonnes)	CI Biomass (tonnes)
[0,0.5]	19700	4	0.29	0.13	0.13	5,783	2,537	7.0	4.1	0.1	0.1
]0.5,2.5]	110100	7	1.65	0.69	0.51	182,133	56,364	44.8	14.8	4.9	1.6
]2.5,5]	430500	9	3.69	0.99	0.64	1,589,196	277,146	103.3	19.2	44.5	8.3
]5,10.3]	165700	6	7.21	1.77	1.41	1,194,065	234,224	171.9	36.0	28.5	6.0
Total	**726000**	**26**				**2,971,177**	**570,272**			**78.0**	**15.9**

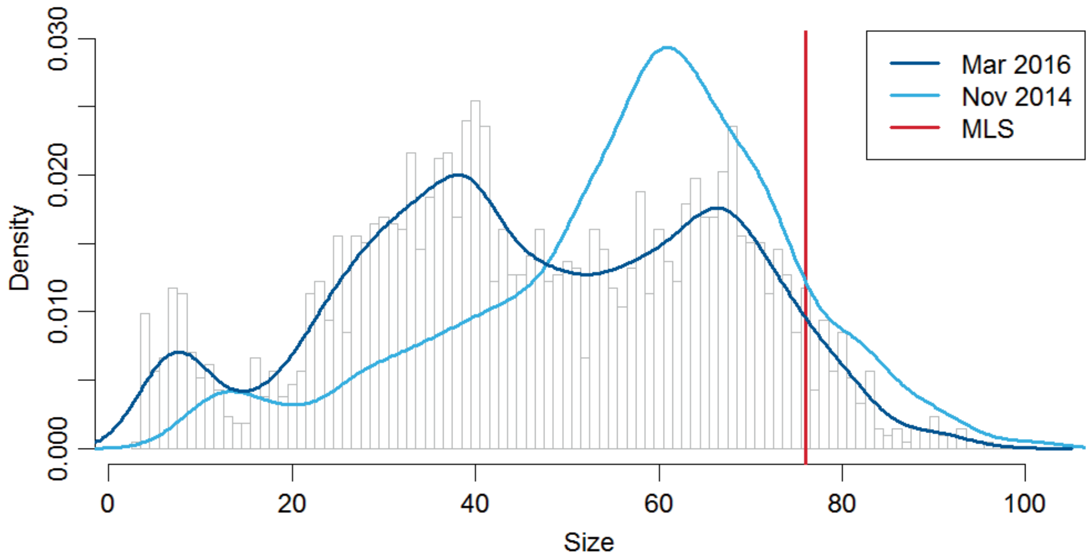

Figure 29. Size distribution of native oysters (*Ostrea edulis*) in south east Galway Bay in March 2016 and November 2014.

8 Scallop (*Pecten maximus*)

8.1 Management advice

Offshore scallop stocks are fished by Irish, UK and French fleets. There is no international assessment. Spatially referenced catch rate indicators have been developed for the Irish fleet in the Celtic Sea, Irish Sea and English Channel. Some inshore stocks are assessed by survey which provides biomass estimate under certain assumptions regarding catchability.

Effort distribution across stocks varies annually. From 2006-2012 catch rates increased in all stocks but declined in the period 2013-2015 in the Celtic Sea and Irish Sea. Catch rates in the eastern Channel are much higher and stable.

Fishing effort / landings should be managed at the stock level in proportion to changes in spatially referenced catch rate indicators using data for all fleets until more comprehensive assessments are developed. Inshore scallop fisheries can have significant negative effects on marine habitats such as geogenic and biogenic reef. Spatial management of scallop fishing should be used to protect such habitats. Offshore scallop fisheries occur mainly on less sensitive sedimentary habitats.

8.2 Issues relevant to the assessment of scallop

No analytical assessments are currently undertaken. Limited size and age data are available from opportunistic sampling of landings from Irish vessels and a series of annual surveys were undertaken in the period 2000-2005 in the Celtic Sea. Spatial variability in growth rates in particular indicates the need for a spatially explicit approach to assessment and therefore the need for spatially explicit and systematic sampling programmes.

A number of other approaches to assessment have been explored including depletion assessment of commercial catch and effort data with variable success.

8.3 Management Units

Offshore scallop in the Irish Sea, Celtic Sea and western and eastern Channel are spatially discrete stocks (Figure 30) following settlement but are variously interconnected during larval dispersal. Larval dispersal simulations show strong connectivity between the south Irish Sea and north east Celtic Sea, limited east west connectivity across the south Irish Sea between stocks off the Irish coast and Cardigan Bay in Wales and general separation of stocks in the eastern Irish Sea and Isle of Man from stocks further south.

Inshore stocks are small and limited in distribution within Bays on the south west and west coasts and regarded as separate populations.

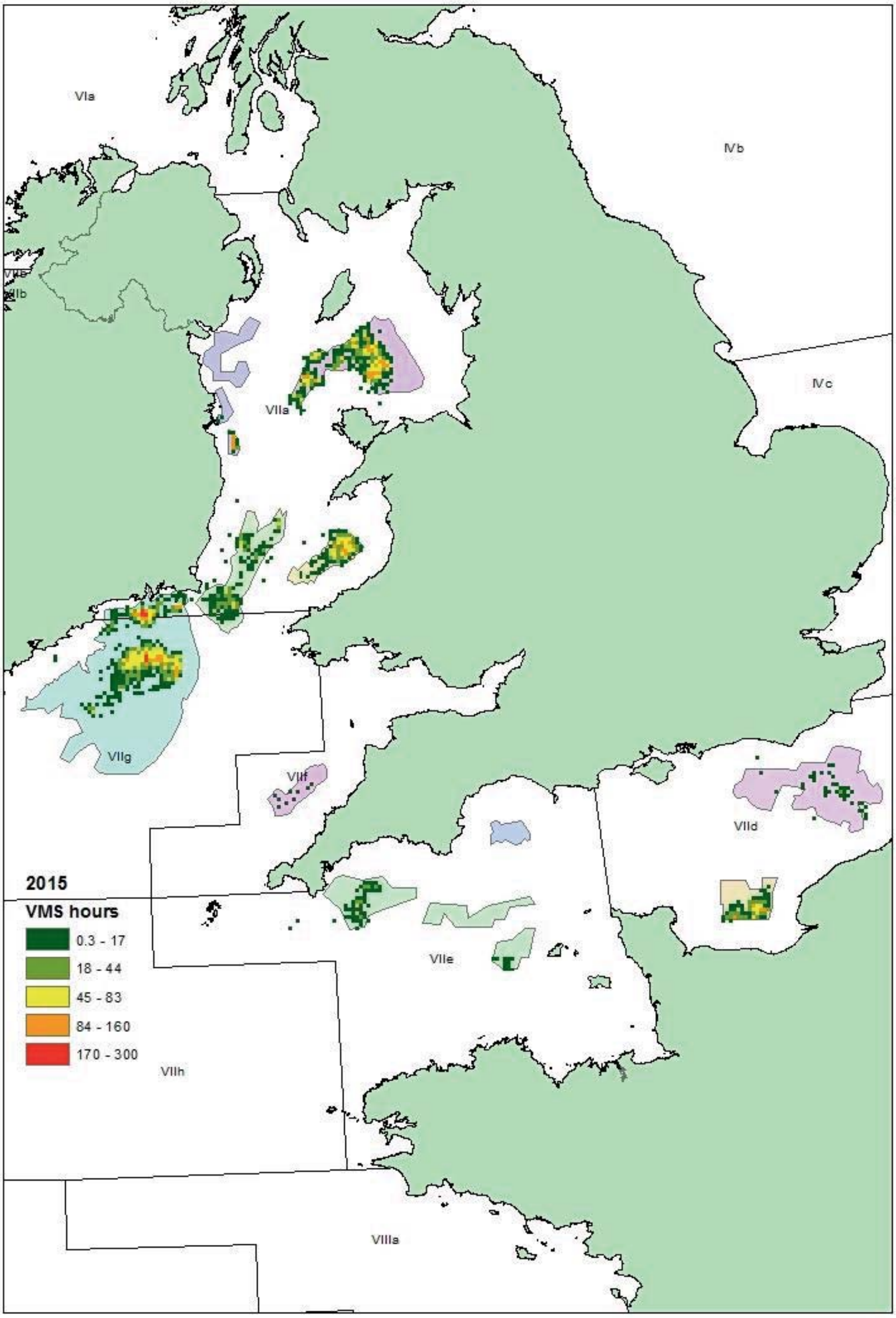

Figure 30. Offshore scallop grounds in the Irish Sea, Celtic Sea and English Channel. Boundaries are defined from the distribution of fishing activity by the Irish fleet 2000-2015 as shown by VMS data. The stock boundary limits are likely to be larger especially in the Irish Sea and English Channel considering that the UK and French fleets fish mainly in these areas. VMS data for 2015 (raster 3km^2 grid) are shown relative to distributional extent of the stocks.

8.4 Management measures

The capacity of the scallop fleet over 10m in length has been limited (ring fenced) since 2006 and an authoriszation is required to fish for scallop. The total annual effort (Kwdays) of the fleet is also capped by the Western Waters agreement (EC 1415/2004). Vessels apply annually for authorizations. Given the relationship between vessel length and dredge number the number of dredges in the fleet can be predicted annually from the length of the vessels authorised (Figure 31). In 2015 the number of dredges on vessels over 10m was approximately 240 compared to an estimated 518 dredges prior to 2006. Vessels under 10m in length are unrestricted.

The minimum landing size is 100mm shell width for most of the offshore stocks other than those in the south Irish Sea where the size is 110mm. The minimum size for inshore stocks is generally 100mm although sizes of up to 120mm are used locally by agreement or as conditions established by shellfish co-operatives that may have aquaculture licences or fishery orders to manage scallop stocks locally eg Kilkieran Bay.

Scallop fishing is excluded from areas supporting sensitive habitats eg seagrass and maerl communities in Roaringwater Bay and reef communities in Blacksod Bay.

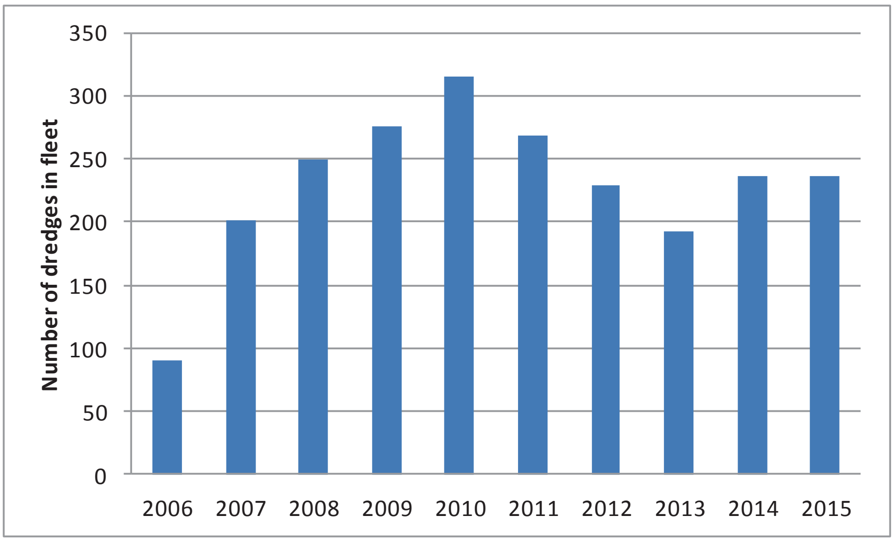

Figure 31. Annual estimated number of dredges in the authorised fleet of scallop vessels over 10m 2006-2015 based on the relationship between vessel length and number of dredges (Dredges = 0.88* Boat length)

8.5 Offshore scallop fisheries

8.5.1 Landings

Landings increased from 1995-2004 due to fleet expansion and expansion of the geographic area fished off the south east coast. The fleet was decommissioned in 2006 and restricted in capacity thereafter and landings consequently declined. New vessels entered the fleet after 2006 and landings continued to increase to over 3000 tonnes in 2013. Landings however declined year on year in 2014 and 2015 (Figure 32).

The Irish fleet fishes in the Irish Sea, Celtic Sea and English Channel. The majority of landings are from the Celtic Sea stock. Fishing in the English Channel is episodic; in recent years the fleet has fished in the eastern Channel while in the period 2000-2006 the fleet fished in the western Channel (Figure 33).

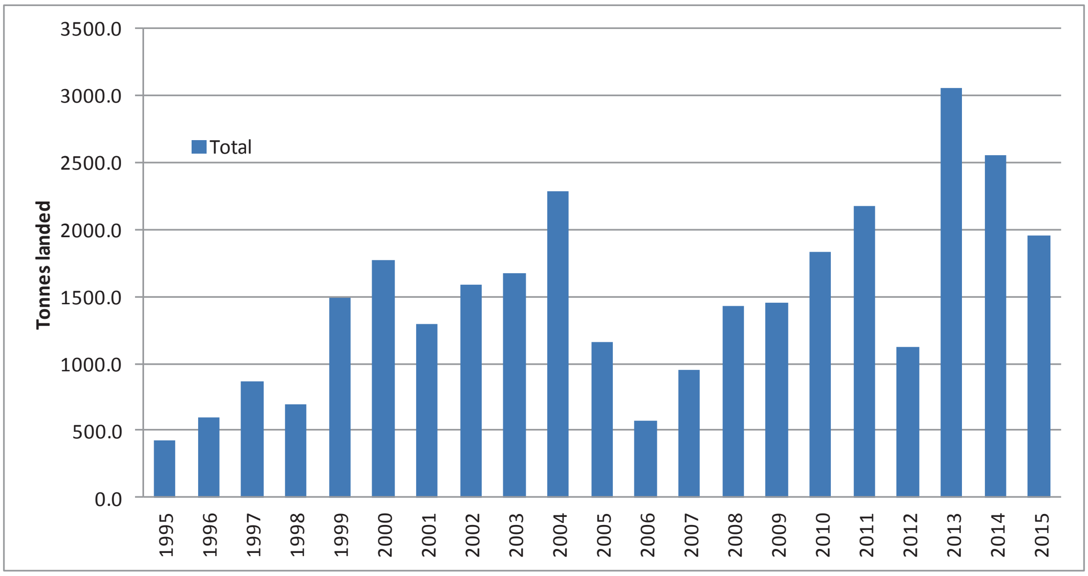

Figure 32. Annual landings of scallop into Ireland 1995-2015.

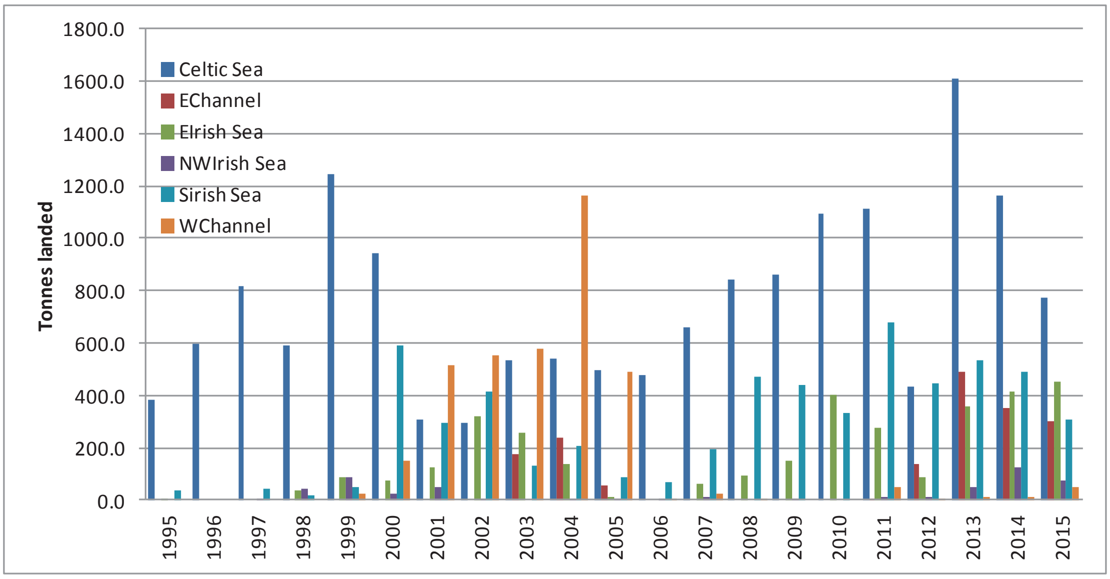

Figure 33. Annual landings by Irish fleet from stocks in the Celtic Sea, Irish Sea and English Channel 1995-2015 (stock locations in Error! Reference source not found.**)**

8.5.2 Fishing effort

The majority of fishing effort by the Irish fleet between 2005-2015 was in the Celtic Sea (Figure 34). Fishing effort increased in the Eastern Irish Sea and south Irish Sea during this period.

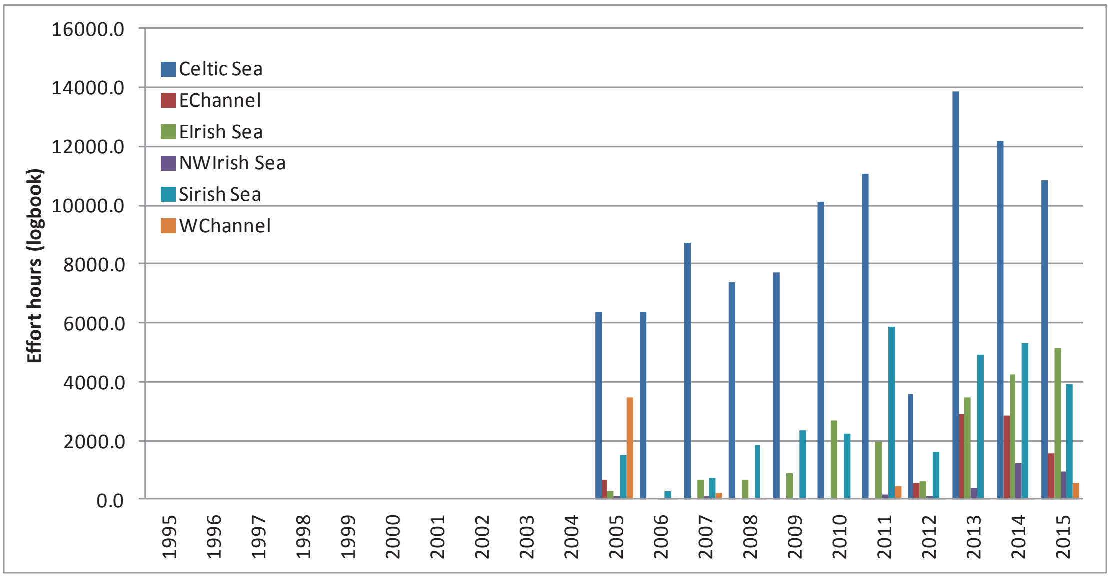

Figure 34. Annual effort hours as reported in logbooks (vessels over 10m) in each stock area 2005-2015

8.5.3 Catch rate indicators

Catch rates kgs.dredge^{-1}.day^{-1} ranged from 30-60 kgs.dredge^{-1}.day^{-1} up to 2006 and increased to 80-100 kgs.dredge^{-1}.day^{-1} by 2012. Catch rates declined from 2012-2015. The exception to these trends is in the Eastern English Channel where catch rates are over 120 kgs.dredge^{-1}.day^{-1}. This Irish fleet fish in this area in quarter 4 (Figure 35).

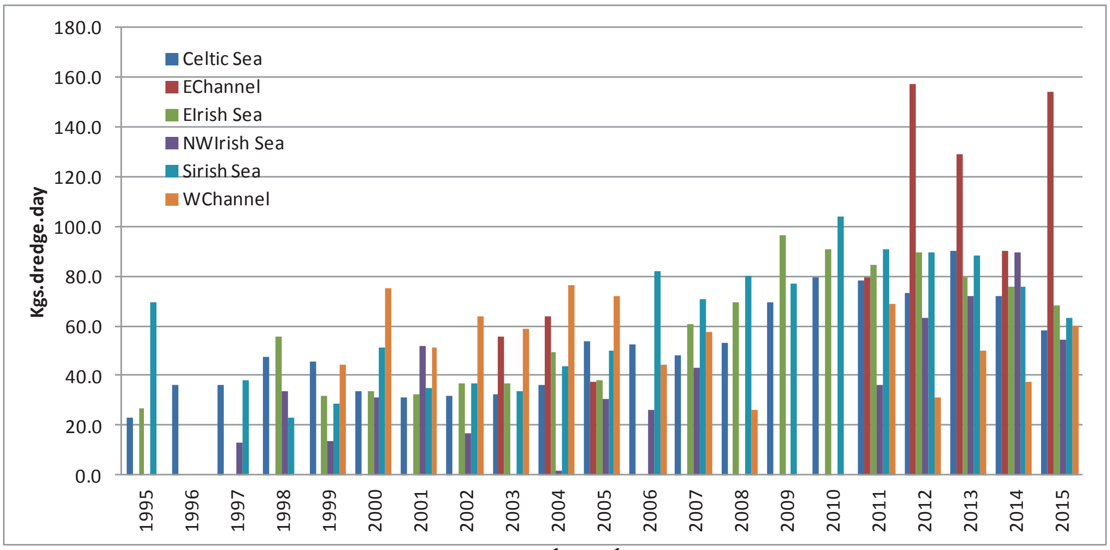

Figure 35. Annual average catch rate (kgs.dredge^{-1}.day^{-1}) of scallop in offshore scallop stocks 1995-2015.

8.5.4 By-catch

Authorised scallop vessels use mainly spring loaded dredges to target scallop on sand and gravel substrate. Fish by-catch is monitored on 4 trips per year by observers. The species composition of the by-catch is shown in Table 17.

Table 17. By-catch species composition (number of fish) in scallop dredges in ICES VIIa and VIIg during 2012-2014.

Species	VIIa	VIIg	Total
Angler-piscatorius	99	82	181
Plaice	138	22	160
Spotted Ray	97	5	102
Dab	81	4	85
Megrim	10	45	55
Common Dragonet	38	5	43
Lesser Spotted Dogfish	26	4	30
Cuckoo Ray	27	2	29
Lemon Sole	13	14	27
Thornback Ray	26		26
Thickback Sole	13	7	20
Poor Cod	13	3	16
Common skate	13	1	14
Angler-budegassa	2	11	13
Dragonet	6	7	13
Whiting	11		11
Flounder	6	1	7
Scaldfish	4	3	7
Red Gurnard	4	2	6
Long Rough Dab	1	4	5
Grey Gurnard	4		4
Solenette	3	1	4
Spotted Dragonet	2	1	3
Sprat	2	1	3
Topknot	2	1	3
Undulate Ray	3		3
Witch		3	3
Black sole	2		2
Hake	2		2
Norway Pout	1	1	2
Pipefish	2		2
Squid	2		2
Bib	1		1
Cod	1		1
Haddock		1	1
Mackerel	1		1
Pogge	1		1
Sandeel	1		1
Snake Pipefish	1		1
Turbot	1		1
Weever-greater	1		1
Grand Total	**661**	**231**	**892**

8.6 Blacksod Bay scallop fishery

The Blacksod Bay scallop stock was first surveyed in 2015 following an intensive fishery in early 2015. The total landings by the fishery in spring of 2015 is unknown but landings of 400-800kgs per boat per day were made during March and April by vessels operating 3-4 dredges. The majority of vessels used single dredges however and daily landings were lower by these vessels. At least 12 vessels, 2 of which used 3-4 dredges participated. Anecdotally 150 tonnes may have been landed in 2015.

A dredge survey was undertaken in July 2015 to assess the status of the scallop stock after the fishery had closed voluntarily in June 2015. DAFM moved to close the fishery on October 1st (Fisheries Natura Declaration 3/2015, www.fishingnet.ie) as the fishery escalated quickly and was located in or close to sensitive biogenic reef (*Serpula vermicularis, Zostera*) in the Bay contrary to the conservation objectives established for the site by the National parks and Wildlife Service (NPWS, www.npws.ie/protectedsites) (Figure 36).

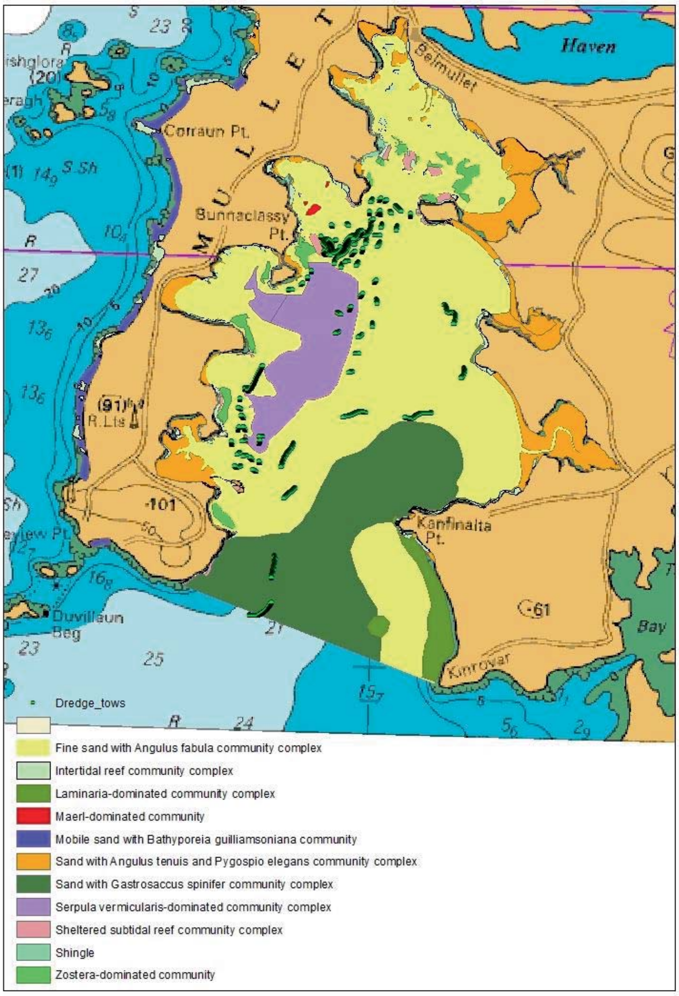

Figure 36. Marine Communities in Blacksod Bay (source: NPWS) showing the location of Serpula reef and the scallop survey dredge tows taken in 2015.

8.6.1 Size and age

Age classes between 3-7 were recorded. Modal size was 115-120 mm. There was little evidence of recent recruitment.

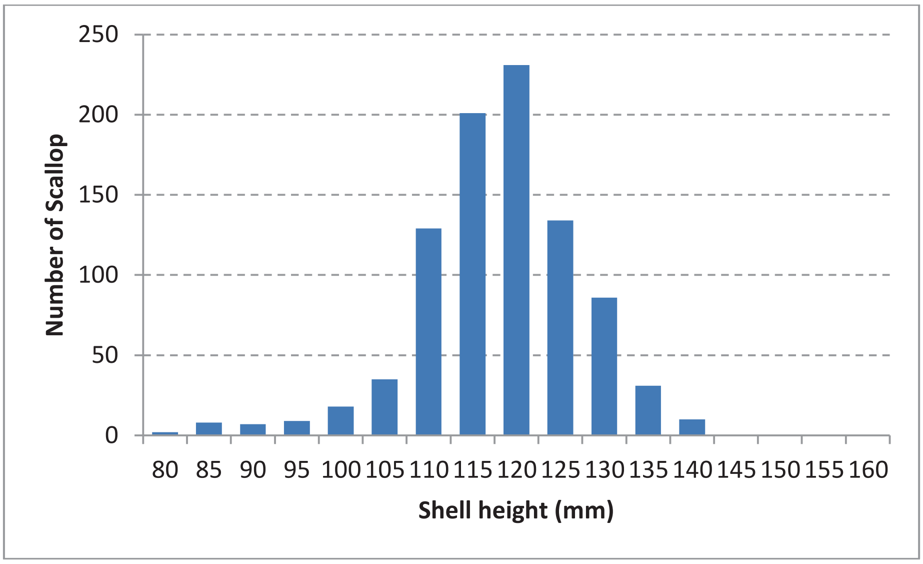

Figure36. Size distribution of scallops in Blacksod Bay 2015 from survey data.

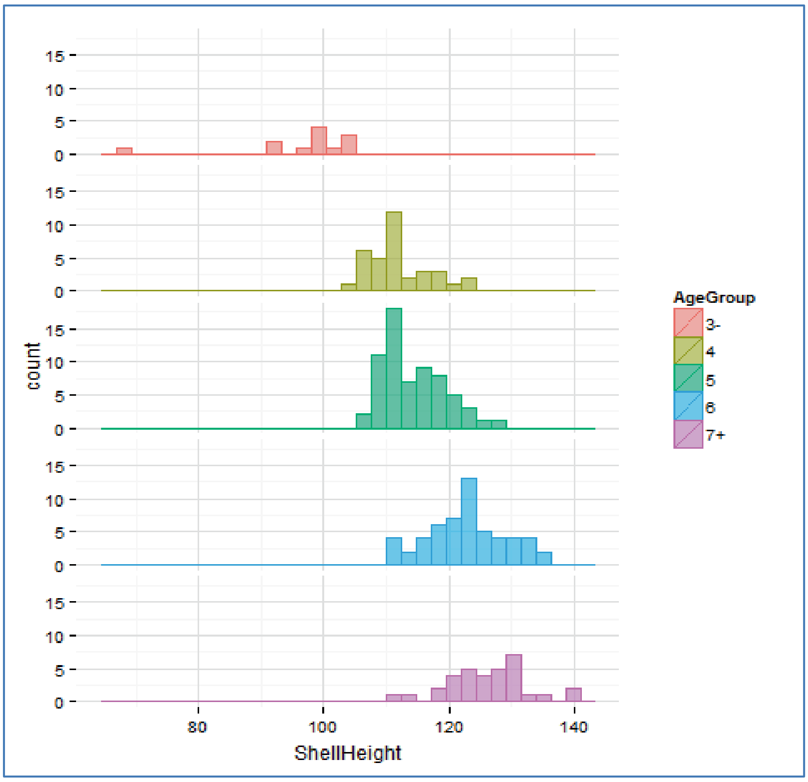

Figure 37. Size at age of scallop in Blacksod Bay in 2015 from survey data.

8.6.2 Distribution and biomass

Scallop were found in 3 patches; in the north of the Bay between Bunnaclassy point and Claggan Point, south of this area east including an area within the *Serpula vermicularis* reef and southwest of this area in shallow water north of Blacksod Point (Figure 37). No scallops were found in the east of the Bay or to the east of Blacksod point.

Densities ranged from 0-0.23 (average 0.03) scallops.m^{-2}. These estimates assume a catchability (dredge efficiency) of 1 (100%). Densities were lowest (< 0.01 scallops.m^{-2}) in the patch of scallops east of the *Serpula* reef and highest in the northern patch between Bunnaclassy Pt. and Claggan Pt. Total biomass within the 3 scallop beds identified in the survey was estimated to be 33 tonnes or approximately 100 tonnes if dredge efficiency is taken at about 33%. This suggests a very high exploitation rate of 60% in spring of 2015.

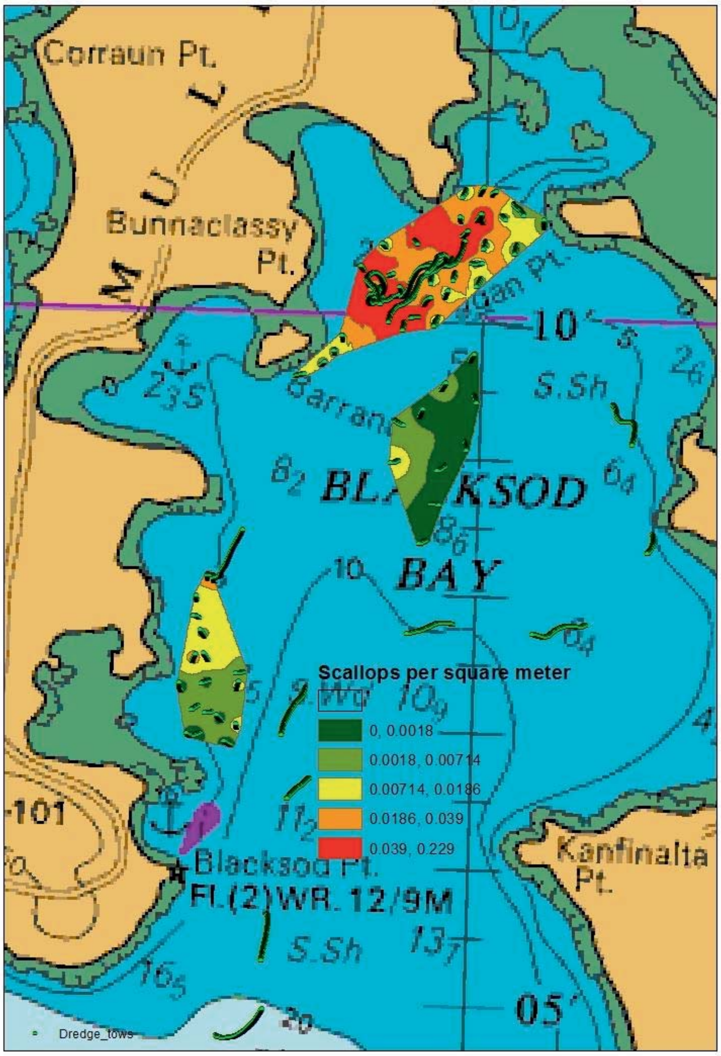

Figure 37. Interpolated scallop densities (scallop.m^{-2}) in 3 areas of Blacksod Bay, July 2015. Stations in the east and south of the Bay are not included in the interpolation. Dredge efficiency assumed to be 100%.

8.6.3 Ecosystem effects

Scallop fishing in Blacksod Bay in the Spring of 2015 occurred in sandy sediments and, according to the habitat map available, in the *Serpula vermicularis* reef. However, there was no evidence of remnants of Serpula reef in the south part of the mapped reef area that had been fished. Reef remnants and some living reef were present in the eastern area of the mapped reef and also outside the mapped reef area. These observations suggest that the margins of the reef area may be changing over time or that the original reef extent was incorrect. Similarly other information from Lidar data indicates the presence of rock outcrops in areas designated as sand in the habitat map. The collective evidence from all data sources, including fishing surveys, could be used to modify both habitat maps and areas where mobile fishing gears are allowed in order to optimise the balance between conservation requirements on the one hand and fishing opportunity on the other.

9 Lobster (*Homarus gammarus*)

9.1 Management advice

Lobsters are assessed using egg per recruit analysis and monitoring of catch rate indicators which includes a pre-recruit index. The egg per recruit analysis assesses the egg production potential of lobsters under different levels of fishing mortality compared to unfished stocks. Egg production of 10% and 35%, of the unfished potential, are thought to be appropriate limit and target reference points respectively.

A minimum landing size of 87mm, a maximum landing size of 127mm and a v-notching rate of 2.5% of landings would increase egg production to over 10% compared to the unfished level. A maximum size of 127mm was introduced in 2015. The proportion of lobsters over 127mm is generally less than 2%. The proportion of lobsters that are v-notched varies from 0-33%. These figures indicate that egg production potential varies by location and, depending on larval dispersal, recruitment may be limited in some areas. V-notching should be focused into these areas.

9.2 Issues relevant to the assessment of lobster

Lobsters cannot be aged. Size distribution data varies spatially and raising to the size distribution of the landings is difficult as spatial effects are strong. These data come from observers who work onboard lobster vessels between May and October mainly.

Some growth rate data are available for Irish stocks from tag returns. Size at maturity has been estimated a number of times.

Egg per recruit assessments are used to compare the relative merits of different technical conservation measures namely size limits and v-notching. Estimating the current position (fishing mortality rate) on the egg per recruit curves is difficult given that this relies on size distribution data and estimates for growth and natural mortality.

Catch rate indicators are available from the sentinel vessel fishery which covers approximately 8% of the fleet. This coverage is insufficient to provide precise estimates of catch rate given the variability in these data in time and space. A number of indicators can be estimated from the data including a recruitment index and an assessment of the % of v-notched lobsters in the catch.

9.3 Management Units

Lobsters are probably distributed as regional stocks along the Irish coast. In 2006 6 management units were proposed. Juvenile and adult lobsters do not move over large areas and the stock structure is determined mainly by larval dispersal.

9.4 Management measures

The lobster fishery is managed using technical measures. The minimum size is 87mm carapace length. A maximum size limit of 127mm was introduced in 2015 following an egg per recruit assessment which showed low egg production. It is prohibited to land v-notched lobsters. The v-notching of lobsters is voluntary. There are no effort or catch limits.

9.5 Data for 2015

9.5.1 Size distribution

A total of 88 observer trips were undertaken on board commercial fishing vessels around the coast of Ireland from April to November 2015. Lobster (*Homarus gammarus*) was sampled during the majority of these trips and a total of 9,005 lobsters were measured. Table 18 indicates the quantity of lobster measured from 15 sampling locations and Figure 38 displays the size distribution of lobster for each of these sampling locations and Figure 39 shows the proportion of lobsters <87mm, 87-127mm and >127mm.

The proportion of lobster ≥[1]127 mm varied around the coast and ranged from 0-10.53%. However, at the majority of locations catches of lobster ≥127 mm represented less than 3% of the total catch. The <3% estimate is consistent with previous years (2001-2014) sampling. North Donegal returned the highest proportion (10.53 %) of lobster ≥127 mm. These vessels were targeting brown crab (*Cancer pagurus*) and were fishing predominately off the coast in deeper water (Figure 1). A high proportion (5.6%) of lobsters ≥127 mm were also recorded off the East coast seaward of 12 nmiles. Again these vessels were fishing in deep water. Less than 1% of lobsters were ≥127 mm in many locations including Sligo, Mayo, Galway Bay, Cork, Waterford, Dublin (inshore) and Louth. In Waterford, Galway Bay (inner) and Sligo the majority of these large lobsters, although there were few of them, were v-notched.

The % of lobsters <87 mm was over 70% in Sligo, Mayo and Dublin (inshore) compared to less than 10% in Galway Bay (outer) and east coast (offshore). Over 50% were <87 mm in Kerry (north), Cork, Waterford and Louth.

The proportion of lobsters between 87 mm and 127 mm (lobsters that can be retained on board and landed if not v-notched) was over 90% in Galway Bay (outer), Dublin (offshore) and was over 50% in Donegal, Galway Bay (inner), Clare, Kerry (west) and Wexford. However, the % of these fish that were v-notched was 33% in Mayo, 22% in Sligo and 11% in Galway and Clare.

[1] ≥(greater than or equal to)

Table 18. Total numbers and proportions of lobster sampled at sea at various locations around the Irish coast during 2015. The proportion of lobster <87 mm, between ≥87 and <127 mm, ≥127 mm are shown along with the proportion of those ≥127 mm with and without a v-notch and the proportion of lobster ≥87 mm with a v-notch.

Location	Total	% <87mm	% ≥87 - <127mm	% ≥127mm	% V-notch	% ≥87mm (with v-notch)	% ≥127mm (with v-notch)
Donegal	38	28.95	60.53	10.53	0.00	0.00	0.00
Sligo	1,422	74.47	24.96	0.56	6.89	**22.59**	**62.50**
Mayo	922	70.61	29.28	0.11	10.63	**33.21**	0.00
Galway Bay Inner	648	38.19	61.60	0.77	8.02	**11.68**	**80.00**
Galway Bay Outer	59	6.78	93.22	0.00	3.39	3.64	0.00
Clare	337	37.98	59.64	2.37	7.12	**11.00**	**25.00**
Kerry North	86	65.12	33.72	1.16	0.00	0.00	0.00
Kerry West	815	35.91	59.39	4.17	1.10	1.18	0.00
Cork West	186	58.60	38.17	3.23	1.08	2.60	0.00
Cork	615	51.35	48.38	0.16	0.33	0.36	0.00
Waterford	1,355	58.75	40.37	0.89	2.95	7.16	**66.67**
Wexford	1,797	47.91	50.75	1.34	1.11	2.14	**16.67**
Dublin	281	73.31	26.69	0.00	0.36	1.33	0.00
East coast offshore	357	3.64	90.76	5.60	1.68	1.74	0.00
Louth	87	55.17	44.83	0.00	0.00	0.00	0.00

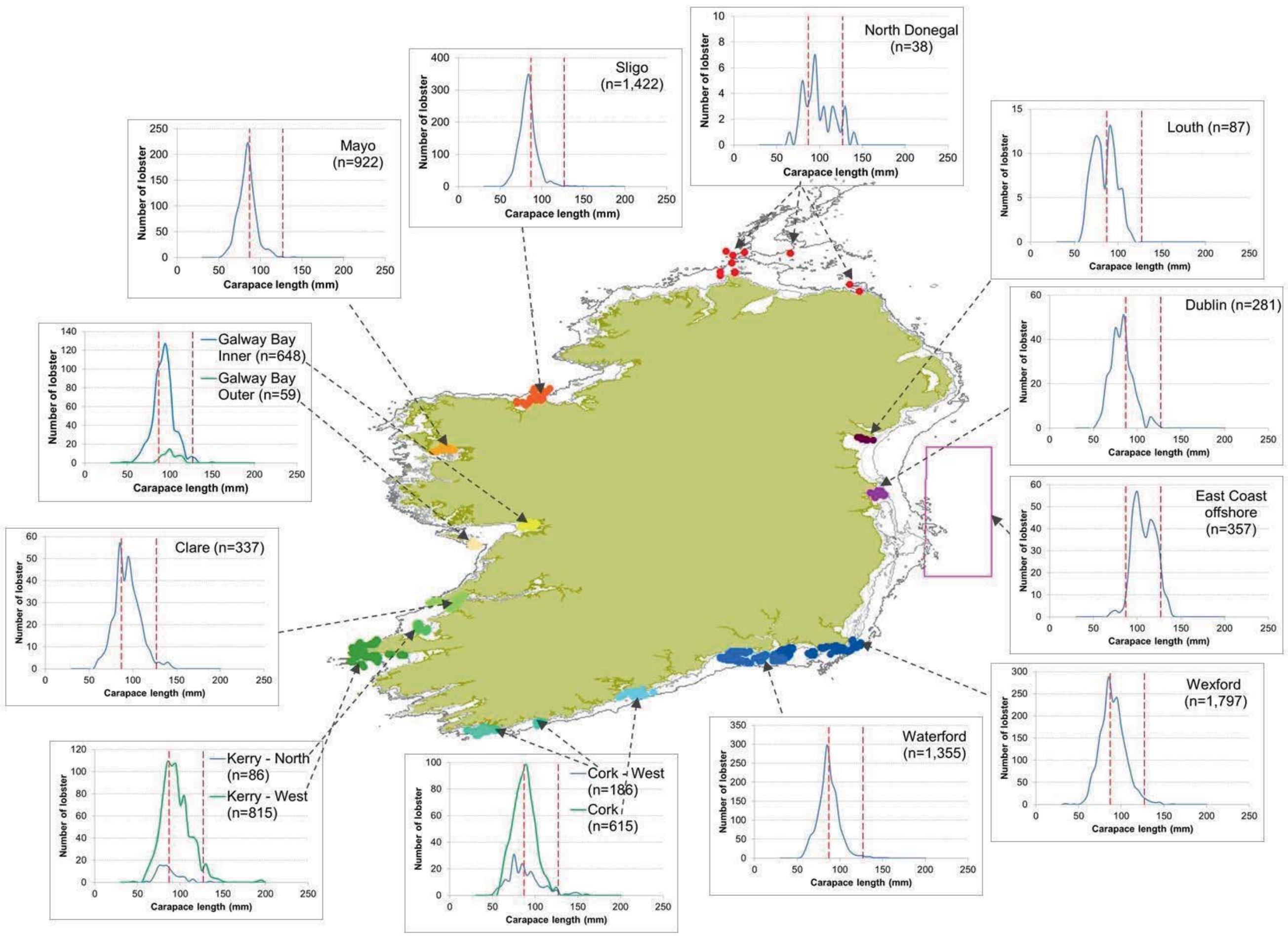

Figure 38. Size distribution data for lobster from different parts of the Irish coast in 2015. The minimum and maximum size limits are shown.

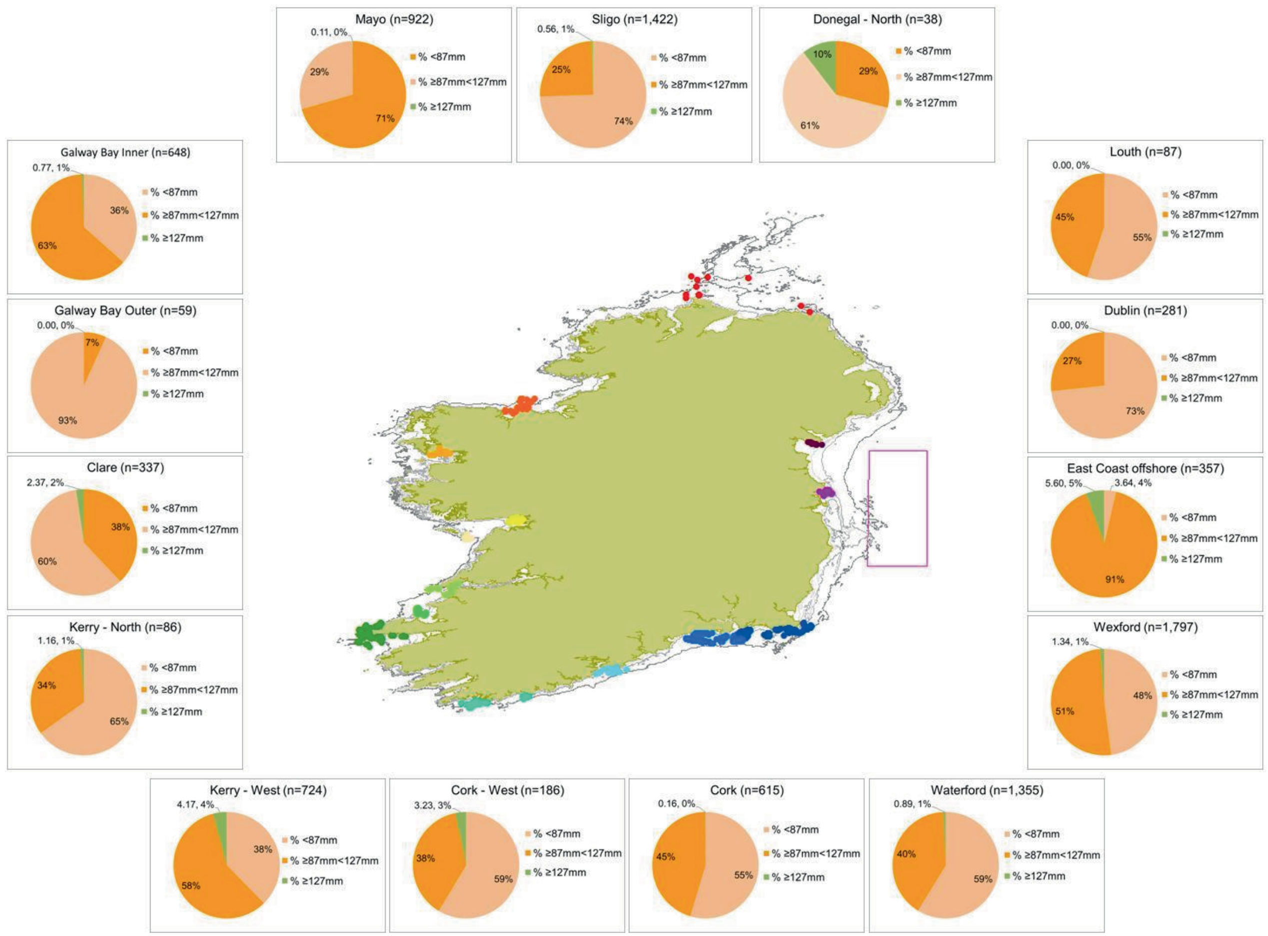

Figure 39. Summary of size distribution data for lobster from different parts of the Irish coast in 2015. The percentage of lobsters <87mm (sub-legal), 87-127mm (legal) and >127mm (over the size limit) are shown.

9.5.2 Maturity

From May to November 2015 the proportion of berried female lobster below the minimum landing size (87mm) ranged from 0-11.46%, with the highest percentage (11.46%) being observed in September when the majority of lobster are expected to extrude new eggs (Table 19). Proportions of berried female lobsters <87 mm at other times was <3%.

Percentages of female lobsters ≥87 mm carrying eggs ranged from 5-34%, with the highest percentages being observed in May and October. For lobsters ≥127 mm the proportions with eggs ranged from 0-60% with the highest percentage being observed in June. All of these fish (berried and unberried) are expected to be physiologically mature but if they spawn every other year the % berried in any given year is not expected to exceed 50% (Table 19).

Table 19. Number of female lobsters recorded each month (May-November 2015) during sampling around the coast of Ireland and the percentage that were carrying eggs. The proportion of berried females <87 mm, ≥87 mm and ≥127 mm are also shown

Month	N Female	% Female Berried	N Female ≥87 mm	N Female ≥127 mm	% Berried <87 mm	% Berried ≥87 mm	% Berried ≥127 mm
May	335	20.60	191	8	2.78	34.03	37.50
June	780	9.23	413	15	0.54	16.95	60.00
July	938	3.09	378	5	1.07	6.08	0.00
August	1202	4.91	530	6	1.64	7.55	0.00
September	879	17.06	495	21	11.46	21.41	28.57
October	265	19.25	149	7	0.86	33.56	14.29
November	40	2.50	20	0	0.00	5.00	0.00

9.6 Size limits and egg production

The average % of lobsters ≥127 mm in the commercial catch was less than 3% and is consistent with previous years data. There are some areas, usually in deeper offshore waters where vessels are targeting crab, where the % of lobsters ≥127 mm is up to 10% by number. These fishing areas are not typical of the Irish lobster fleet which fishes close in shore for the most part.

The prevalence of v-notched lobsters varies around the coast but is generally < 3% of all lobsters and 6.6% of commercial size lobsters. There are v-notch 'hotspots' in Mayo, Sligo and to a lesser extent West Clare and Inner Galway Bay. The variation in % of lobsters that are v-notched is a reflection of the numbers released in recent years in different areas of the coast, their survival, the rate at which they repair the notch at moult and movement between areas. It suggests that egg production from v-notched lobsters is very important in some areas but is not significant contributor in many areas particularly on the south coast.

18% of lobsters ≥127 mm were v-notched. This relatively low percentage, which could include recaptures of fish notched in 2015 under the derogation to land fish >127mm for v-notching, suggests that relatively few lobsters grow to 127 mm before the notch is repaired and fish can be landed. Targeting larger fish for notching would increase the % escaping into the 127 mm size refuge.

Egg production potential in the stock needs to be maintained between 10-35% of the unexploited level. Previous assessments indicated that a combination of minimum size of 87 mm, v-notching of 2.5% of the catch of commercial sized lobsters and a maximum size of 127 mm would increase egg production above 10% of the unfished level. The low prevalence of v-notched lobsters in many areas suggests that this is not being achieved and that additional measures are needed to protect spawning potential. The higher % of lobsters over 127 mm in some areas and the high % of v-notched lobsters in others, however, indicate good spawning potential in these areas. Whether recruitment from these areas 'spills over' into others is unknown but the variability in the level of protection afforded to lobsters by the current technical measures on different parts of the coast points to the need for a more geographically focused v-notch programme into areas where the number of v-notched fish are currently at low levels.

Variability in the size composition of lobsters around the coast has a significant impact on the economic viability of lobster fishing as discarding rates increase with the addition of extra technical measures. The 127mm measure represents a loss of production to the fishery compared to the minimum size and v-notch measures which represent temporary losses which eventually recruit to the fishable stock. The conservation effects of the measures however may, over time, increase recruitment to the legal component of the catch. An alternative approach is to manage the overall annual fishing mortality rate or harvest rate which would in the medium term result in changes to the size distributions, improve yields and reduce costs.

10 Glossary

Accuracy A measure of how close an estimate is to the true value. Accurate estimates are unbiased.

Benthic An animal living on, or in, the sea floor.

Bonamia (ostrea) A parasite of native oyster which infects the blood cells and causes mortality of oysters.

Biomass Measure of the quantity, eg metric tonne, of a stock at a given time.

Bi-valve A group of filter feeding molluscs with two shells eg scallops, cockles.

Cohort (of fish) Fish which were born in the same year.

Cohort analysis Tracking a cohort of fish over time. Length cohort analysis tracks length classes over time using growth data

Demersal (fisheries) Fish that live close to the seabed and are typically targeted with various bottom trawls or nets.

Ecosystems are composed of living animals, plants and non living structures that exist together and 'interact' with each other. Ecosystems can be very small (the area around a boulder), they can be medium sized (the area around a coral reef) or they can be very large (the Irish Sea or even the eastern Atlantic).

Exploitation rate The proportion of a population at the beginning of a given time period that is caught during that time period (usually expressed on a yearly basis). For example, if 720,000 fish were caught during the year from a population of 1 million fish alive at the beginning of the year, the annual exploitation rate would be 0.72.

Fishing Effort The total fishing gear in use for a specified period of time.

Fishing Mortality Deaths in a fish stock caused by fishing usually reported as an annual rate (F).

Fishery Group of vessel voyages targeting the same (assemblage of) species and/or stocks, using similar gear, during the same period of the year and within the same area (e.g. the Irish flatfish-directed beam trawl fishery in the Irish Sea).

Fishing Licences A temporary entitlement issued to the owner of a registered fishing vessel to take part in commercial fishing.

Fleet Capacity A measure of the physical size and engine power of the fishing fleet expressed as gross tonnage (GTs) and kilowatts (KWs).

Fleet Segment The fishing fleet register, for the purpose of licencing, is organised in to a number of groups (segments).

Management Plan is an agreed plan to manage a stock. With defined objectives, implementation measures or harvest control rules, review processes and usually stakeholder agreement and involvement.

Management Units A geographic area encompassing a 'population' of fish de-lineated for the purpose of management. May be a proxy for or a realistic reflection of the distribution of the stock.

Minimum Landing Size (MLS) The minimum body size at which a fish may legally be landed.

Natura A geographic area with particular ecological features or species designated under the Habitats or Birds Directives. Such features or species must not be significantly impacted by fisheries.

Natural Mortality Deaths in a fish stock caused by predation, illness, pollution, old age, etc., but not fishing.

Polyvalent A type of fishing licence. Entitlements associated with these licences are generally broad and non-specific. Vessels with such licences are in the polyvalent segment of the fishing fleet.

Precision A measure of how variable repeated measures of an underlying parameter are.

Quota A portion of a total allowable catch (TAC) allocated to an operating unit, such as a Vessel class or size, or a country.

Recruitment The amount of fish added to the exploitable stock each year due to growth and/or migration into the fishing area. For example, the number of fish that grow to become vulnerable to the fishing gear in one year would be the recruitment to the fishable population that year. This term is also used in referring to the number of fish from a year class reaching a certain age. For example, all fish reaching their second year would be age 2 recruits.

Recruitment overfishing The rate of fishing, above which, the recruitment to the exploitable stock becomes significantly reduced. This is characterised by a greatly reduced spawning stock, a decreasing proportion of older fish in the catch, and generally very low recruitment year after year.

Reference points Various reference points can be defined for fished stocks. These can be used as a management target or a management trigger (i.e. point where more stringent management action is required). Examples include fishing mortality rate reference points, biomass reference points, indicator eg catch rate reference points or those based on biological observations.

Sales Notes Information on the volume and price of fish recorded for all first point of sale transactions.

Shellfish Molluscan, crustacean or cephalopod species that are subject to fishing.

Size composition The distribution, in size, of a sample of fish usually presented as a histogram.

TAC Total Allowable Catch

Vivier A fishing vessel, usually fishing for crab, with a seawater tank(s) below decks, in which the catch is stored live.

VMS Vessel Monitoring System

"a thriving maritime economy in harmony with the ecosystem and supported by the delivery of excellence in our services"

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